



Project Cost and Schedule Risk Analysis

A presentation to:

NASA Project Management Challenge 2006

David T. Hulett, Ph.D.
Hulett & Associates, LLC



(310) 476-7699 / info@projectrisk.com

Defining Project “Risk”



-
- Project risk is an uncertain event or condition that, if it occurs, has a positive or negative effect on at least one project objective.*

****Guide to the Project Management Body of Knowledge
(PMBOK® Guide), 3rd Edition, © 2004 Project Management Institute***

Threats vs. Opportunities



- Positives are opportunities for the project manager
 - Need to know where to find opportunities
 - Need to know how to take advantage of opportunities
- Using opportunities
 - If an early activity is late, time might be made up on later work
 - Sometimes the company can make an opportunity happen

Risk Management Processes



-
- Risk Management Planning
 - Risk Identification
 - Qualitative Risk Analysis
 - **Quantitative Risk Analysis**
 - Risk Response Planning
 - Risk Monitoring and Control

Source: *Guide to the Project Management Body of Knowledge, (PMBOK® Guide), 3rd Edition, © 2004 Project Management Institute*

Quantitative Risk Analysis Context



-
- Generally performed after Qualitative Risk Analysis
 - Some projects proceed directly from Risk Identification
 - Some projects do not practice Quantitative Risk Analysis at all, preferring to stay with priority lists of risks from Qualitative Risk Analysis

Purpose: To Quantify Overall Project Risk



- Numerical analysis of the effect of all risks simultaneously on project objectives
- Quantify the possible outcomes, and probabilities of achieving those outcomes
- Quantify likelihood of achieving success with the current plan or with alternatives – “what if” analysis
- Identify risks requiring the most attention – high priority – when all risks are considered simultaneously



Modeling and Simulation Tools

Why Monte Carlo Simulation?



-
- Traditional approach to cost or schedule calculation
 - Estimate each element. Assume estimates are certain
 - Cost estimation → add up the estimates for total cost
 - Scheduling → Calculate [F-9] the schedule
 - We now understand that the estimates are not certain
 - Represent them with probability distributions
 - Cannot “sum” distributions. How can we “combine” distributions?
 - Monte Carlo Simulation is the answer

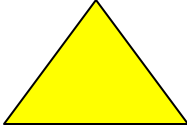

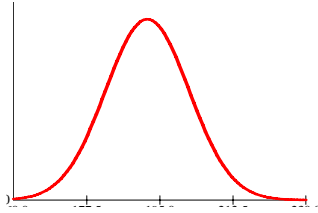
Monte Carlo Simulation Approach



- Find all possible combinations of the uncertain costs or durations
- The computer “performs” the project many times
 - These are called “iterations”
 - Different values (costs, durations) are “chosen” at random from the elements’ distributions for each iteration
 - Calculate the project cost or schedule for that iteration
- Plot a probability distribution of total cost or completion date

Summation vs. Simulation



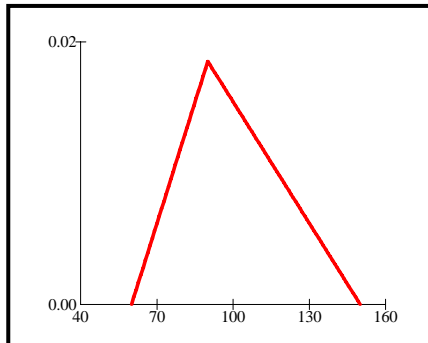
Compare Traditional Estimation with Simulation (Cost Risk Illustration)		
Software Project Component	Traditional Estimate	Probability Distributions
Coding	120	
Testing	65	
Total Project Cost	185	

Example Iteration -- Cost Estimate and Ranges

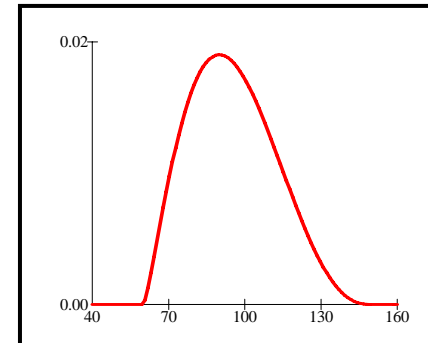


		Risk Range	
Cost Element	Optimistic	Traditional Estimate	Pessimistic
Coding	105	120	145
Testing	60	65	80
Total Project Cost		185	

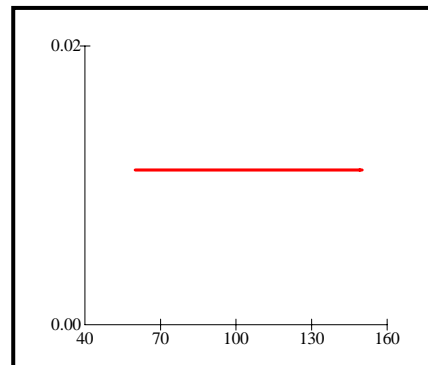
Some Popular Distributions



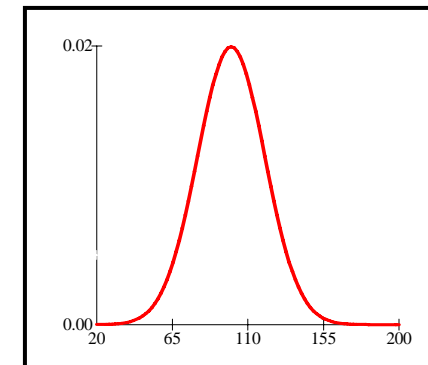
Triangular



Beta

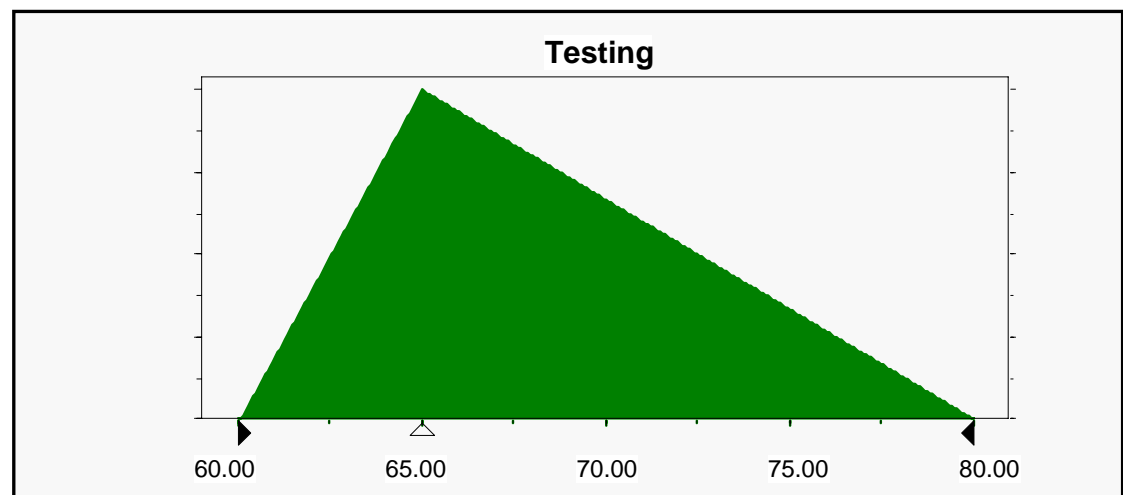
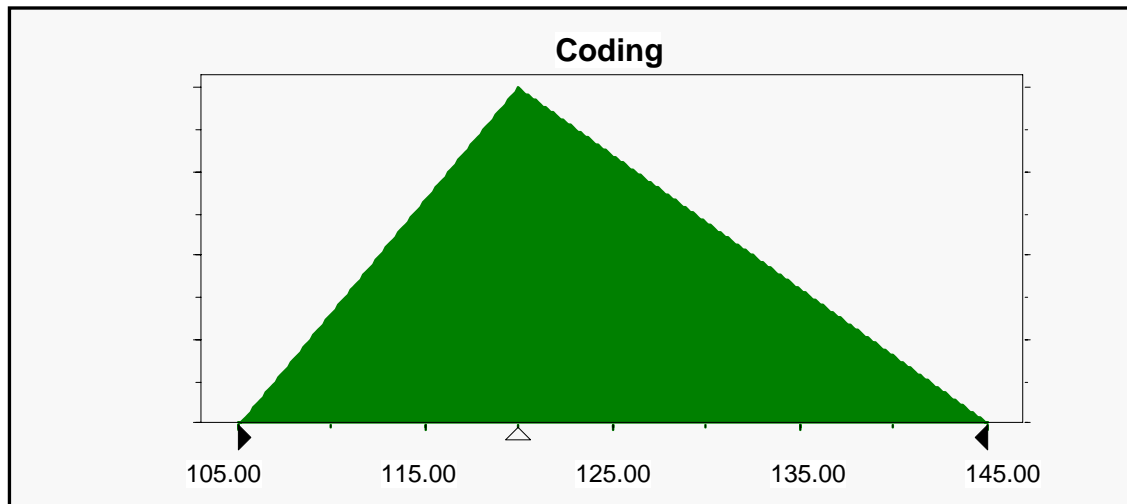


Uniform



Normal

Triangular Distributions



Examples of Three Iterations



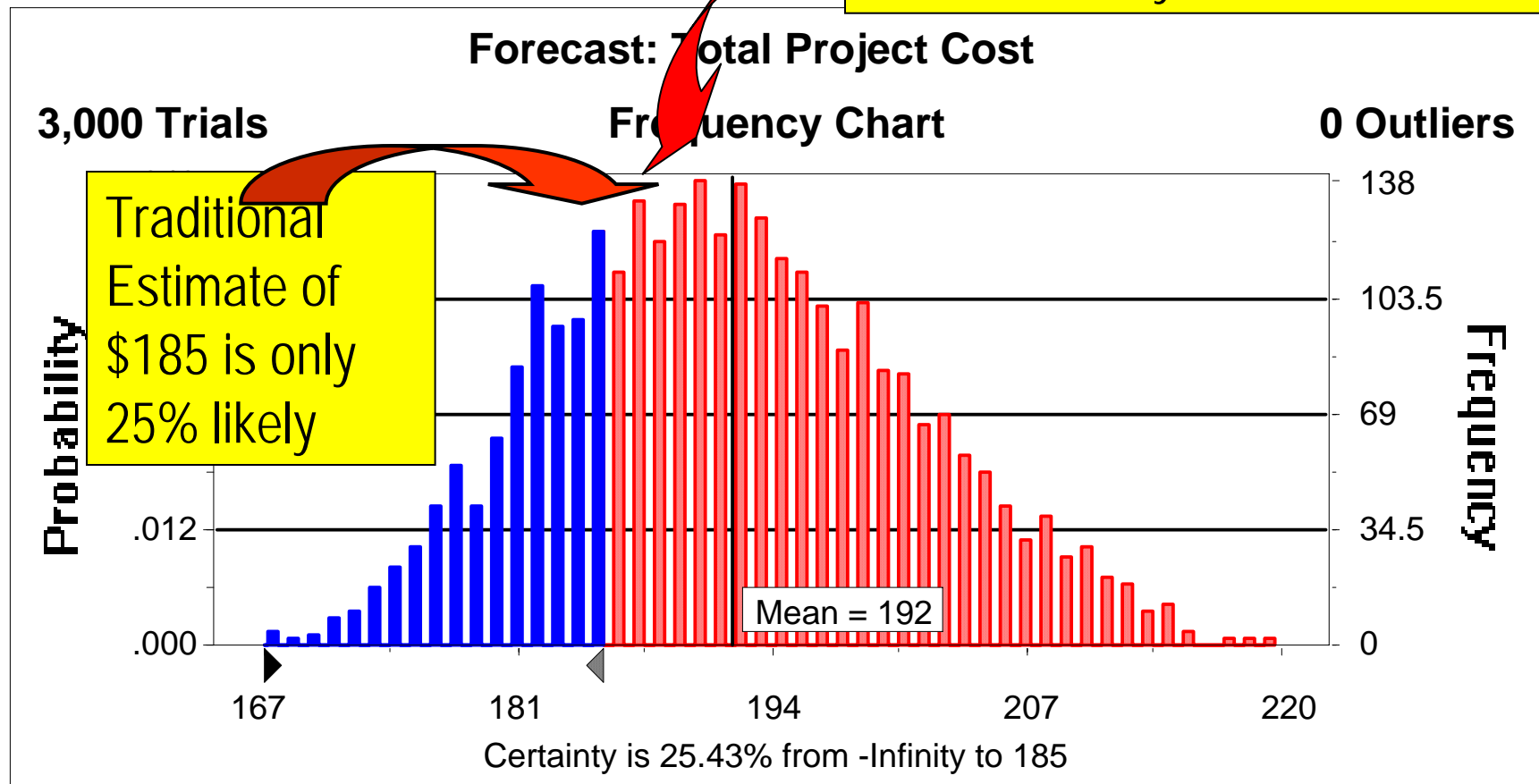
- Three iterations out of 3,000
- Select the costs at random
- Add them up
- Store the results of each iteration

Three Iterations			
Cost Element	# 1	# 2	# 3
Coding	129.2	124.7	108.3
Testing	69.2	65.1	65.6
Total Project Cost	198.4	189.8	173.9

Simulation Results with 3,000 Iterations



Traditional Estimate is not even the Most Likely Total Cost





Cost Risk Analysis

Cost Risk Analysis: Purpose



To provide the project manager with a cost that has an acceptable probability of being exceeded

Source: Paul Garvey, the Mitre Corporation

Cost Risk – “Three Promises”



-
- Cost risk analysis promises:
 1. Likelihood of alternative possible costs
 2. Level of exposure to overruns and need for contingency
 3. Project activities that pose the greatest cost risk
 - The company determines:
 - Exposure level that is “acceptable”
 - Should we do risk mitigation?

Quantitative Risk Analysis is Not New



- “Initial cost and schedule estimates for major projects have invariably been over-optimistic. The risk that cost and schedule constraints will not be met cannot be determined if cost and schedule estimates are given in terms of single points rather than distributions.”

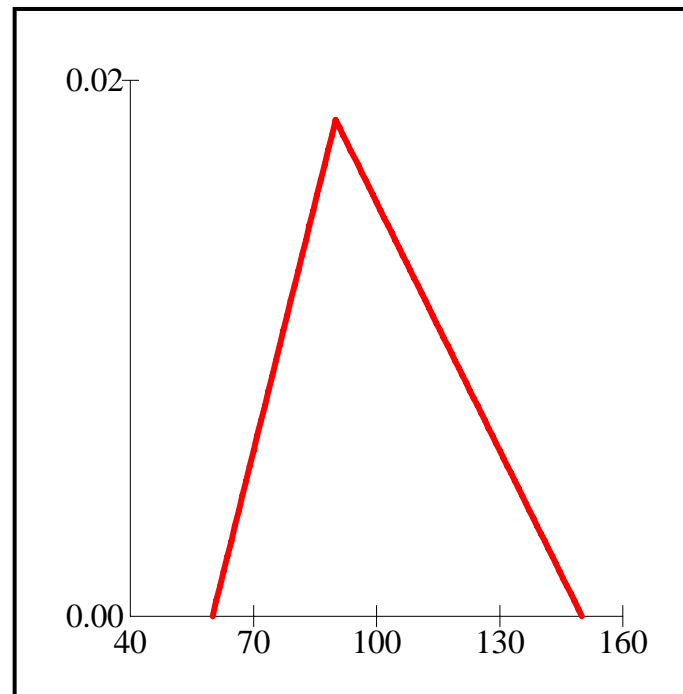
Quantitative Risk Analysis is Not New (continued)



- “A formal risk analysis is putting on the table those problems and fears which heretofore were recognized but intentionally hidden.”

Source: "*Final Report*,"
US Air Force Academy
Risk Analysis Study Team 1973

Line Item Mean Value: Triangular Distribution



$$\begin{aligned}\text{Mean value} &= (\text{low} + \text{most likely} + \text{high}) / 3 \\ &= (60 + 90 + 150) / 3 = 100\end{aligned}$$

Line Item Standard Deviation (sigma): Triangular Distribution

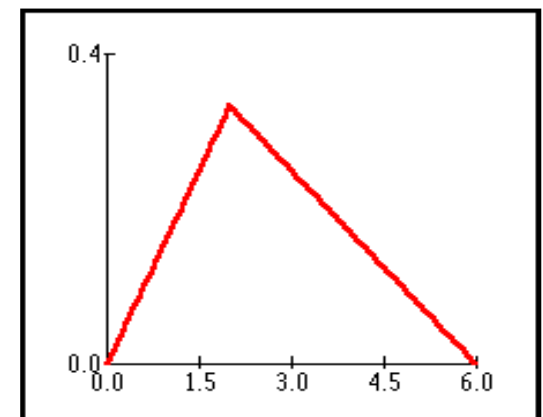


$$\text{Sigma} = \sqrt{\{(H-ML)^2 + (H-ML)*(ML-L) + (ML-L)^2\}/18}$$

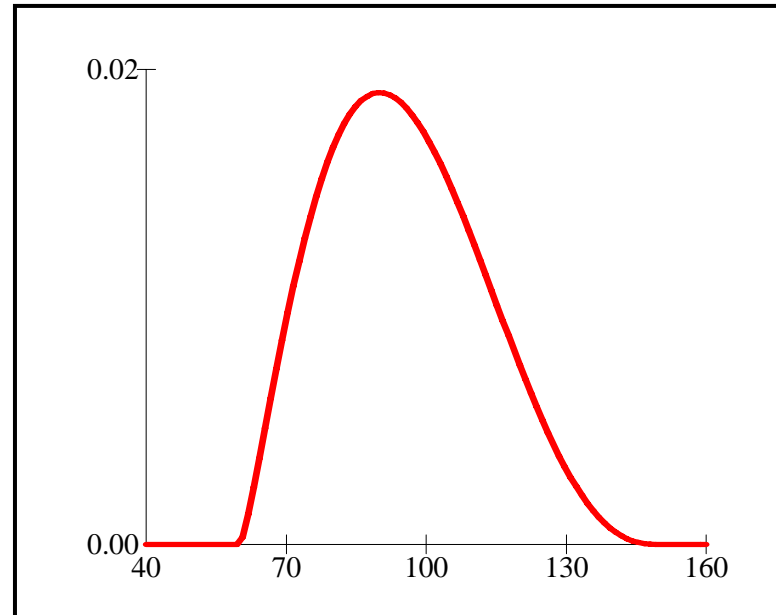
$$\text{Sigma} = \sqrt{\{(150-90)^2 + (150-90)*(90-60) + (90-60)^2\}/18}$$

$$\text{Sigma} = \sqrt{\{60^2 + 1800 + 30^2\}/18}$$

$$\sqrt{6300 / 18} = \sqrt{350} = 18.7$$



Beta Continuous Probability Distribution

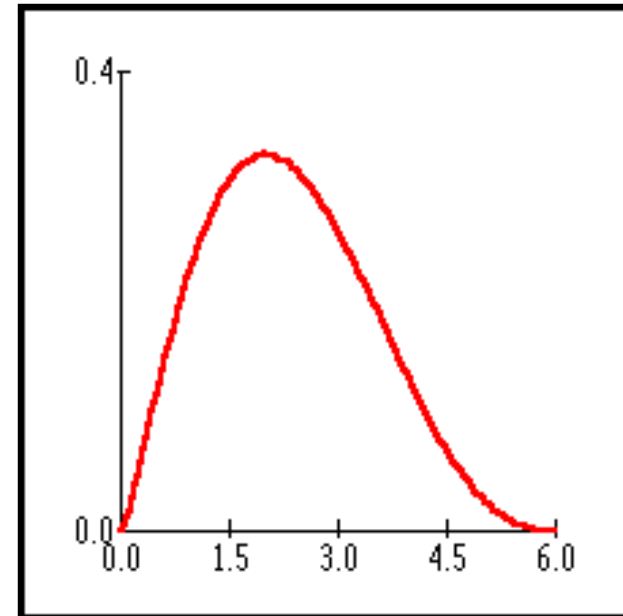


Mean value = Approximately
(there are many Beta Distributions
(low + 4*most likely + high)/6
Mean value = $(60 + 4*90 + 150) / 6 = 95$

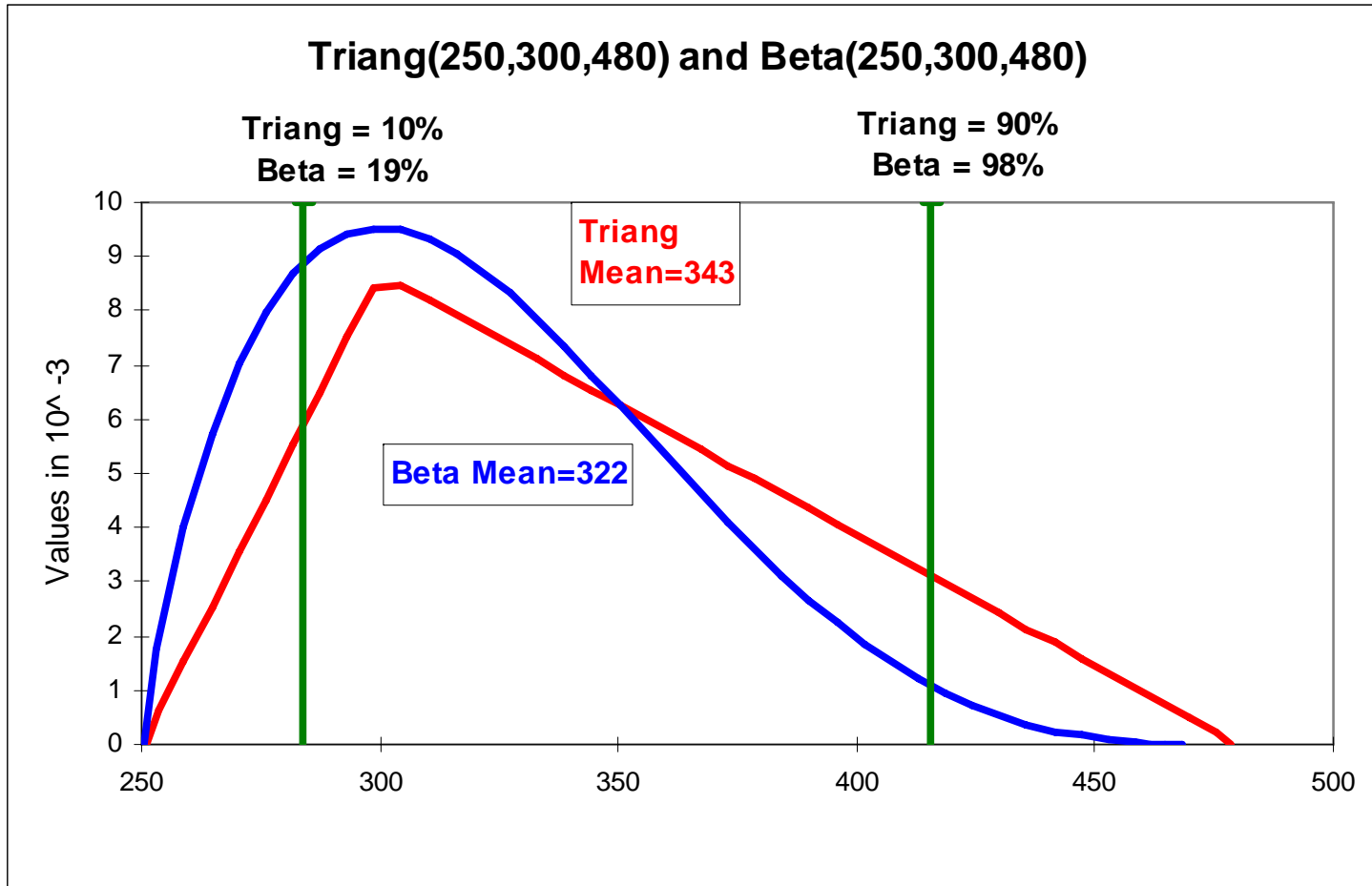
Standard Deviation (sigma): Beta Distribution



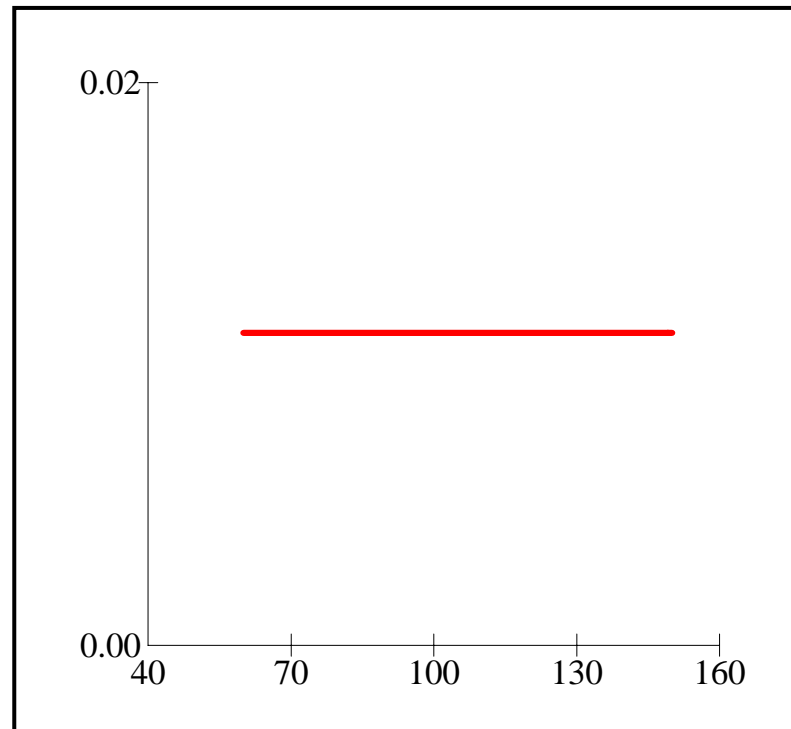
- $\text{Sigma} = (H - L) / 6$ approx.
- $\text{Sigma} = (150 - 60) / 6 = 90 / 6$
- $\text{Sigma} = 15$
- The actual standard deviation for this Beta PERT is 16.6



Compare the Triangular and Beta PERT



Uniform Continuous Probability Distribution

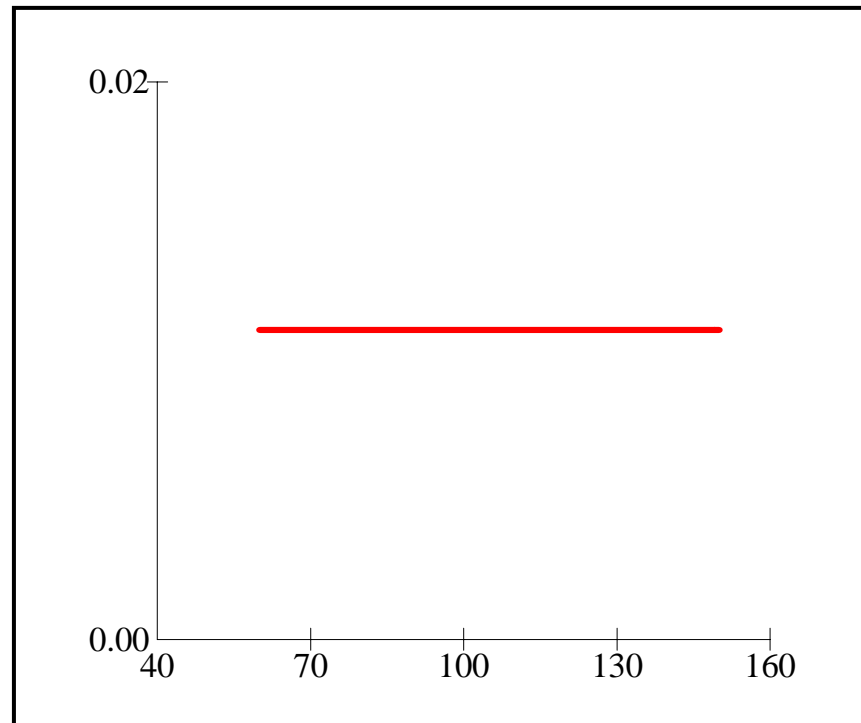


$$\text{Mean value} = (\text{low} + \text{high}) / 2$$
$$\text{Mean value} = (60 + 150) / 2 = 105$$

Uniform Continuous Probability Distribution



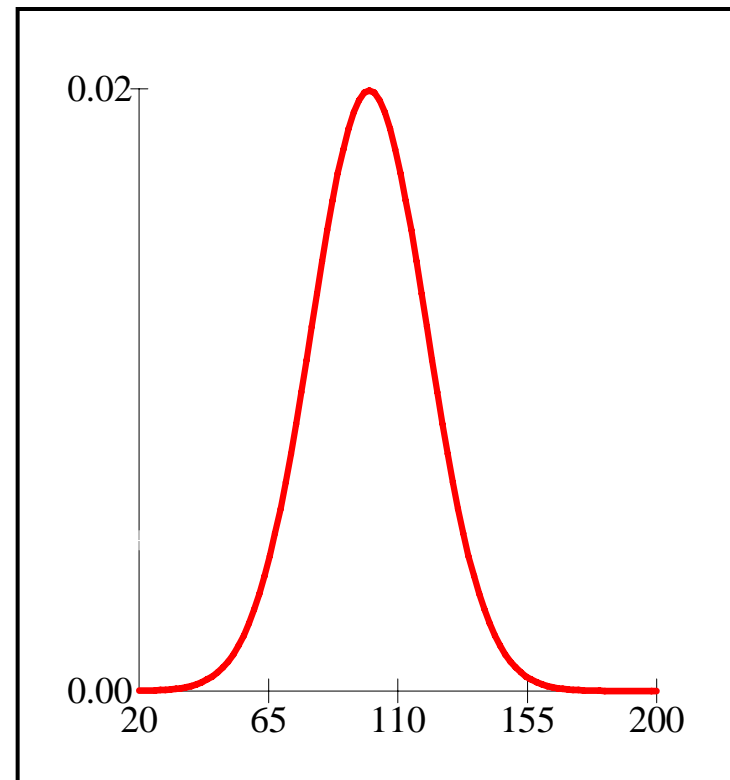
- Variance = $(H - L)^2 / 12$
- Sigma = $\sqrt{(H - L)^2 / 12}$
- Variance = $(150-60)^2/12$
- Variance = $8100/12 = 675$
- Sigma = $\sqrt{675} = 26$



Normal Continuous Probability Distribution



- Must be symmetrical
- Not much value in project risk management
- Here is a normal (Gaussian) with mean 100 and standard deviation 20



Some Popular Distributions Compared



Probability Distributions Compared		
Range (60 - 90 - 150)		
Type	Mean	Sigma
Uniform	105	26.0
Triangular	100	18.7
Beta PERT	95	15.0

Estimate this Project's Cost



- Will this project cost \$4,280,000? Are you sure?

Project Cost Estimate	
Cost Element	Estimate (000)
Design	250
Materials	500
Procured Components	830
Tooling	375
Fabrication	780
Assembly	645
Integration	500
Testing	400
Total Project Cost	4,280

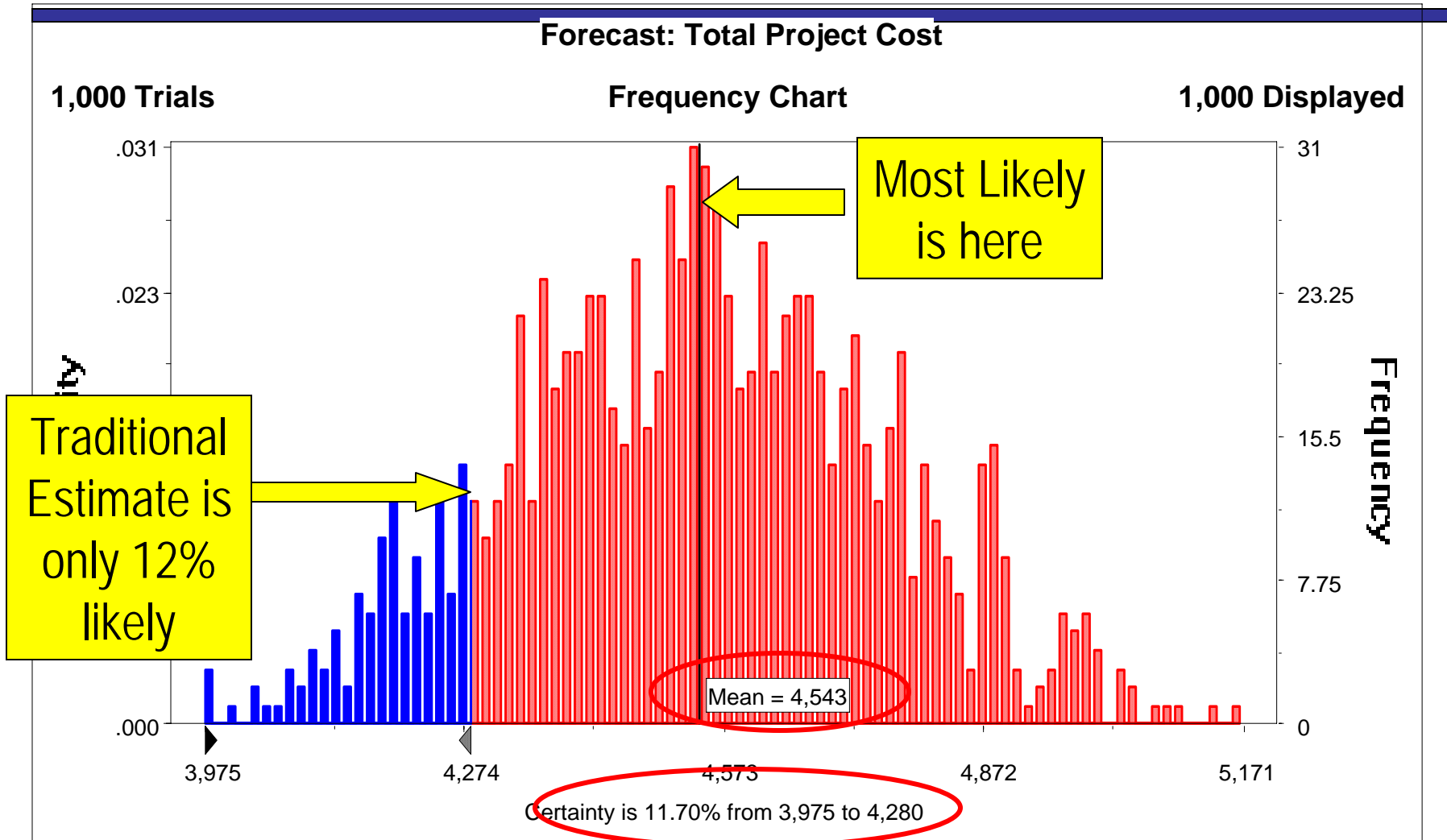
Same Project, Risks Examined



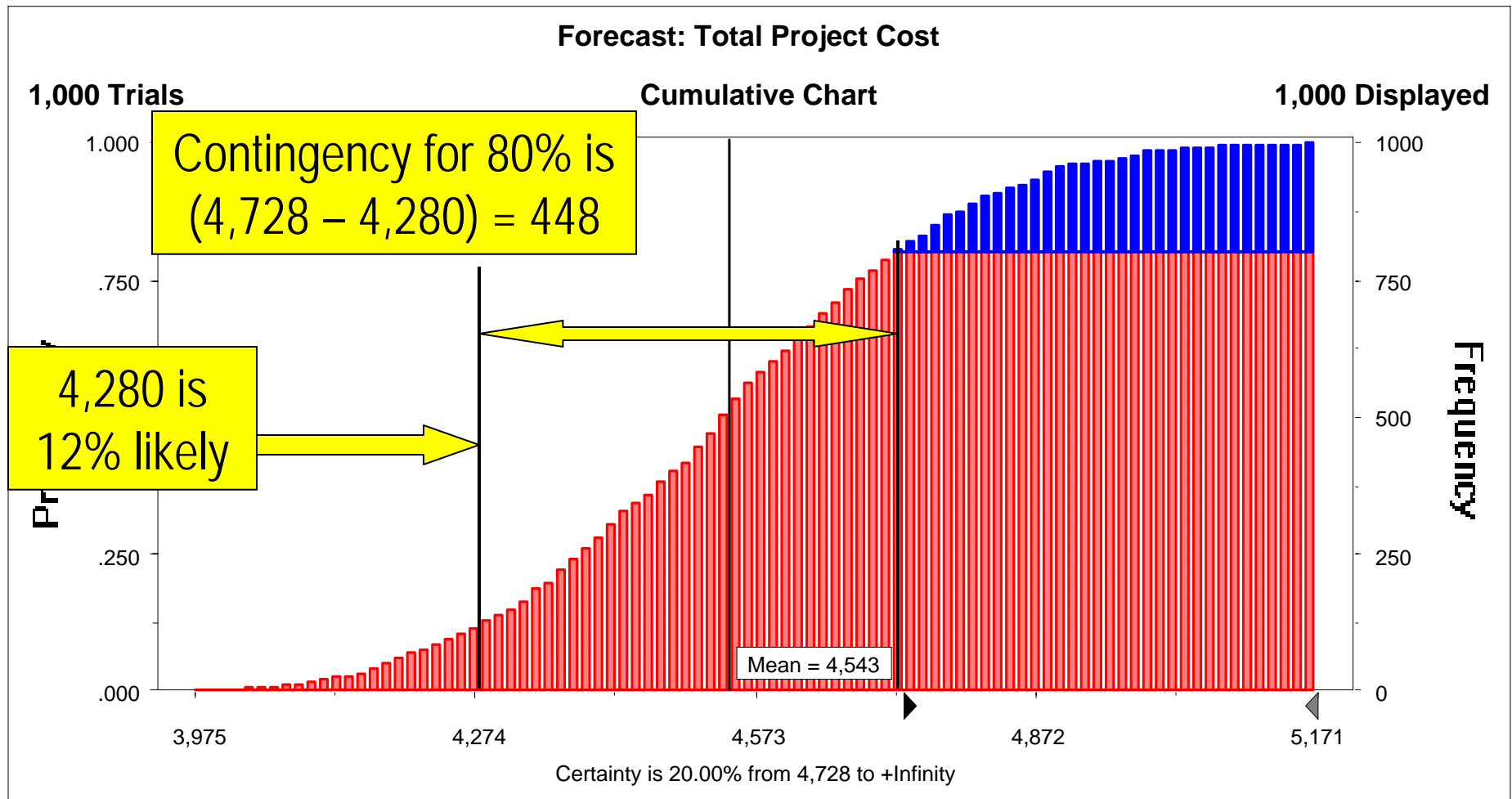
- Interview experts about optimistic and pessimistic

Project Cost Estimate Risk Analysis			
Cost Element	Estimate (000)	Optimistic	Pessimistic
Design	250	175	425
Materials	500	350	750
Procured Components	830	700	1,000
Tooling	375	300	570
Fabrication	780	650	910
Assembly	645	500	900
Integration	500	375	735
Testing	400	260	750
Total Project Cost	4,280		

Cost Risk: Results of the Monte Carlo Simulation



Cumulative Distribution is used for Exposure and Contingency



Contingency Needed For Each Exposure Level



Contingency Needed for Levels of Exposure to Risk		
Percentile	Value	% Contingency
0%	3,975	-7%
10%	4,261	0%
20%	4,360	2%
30%	4,424	3%
40%	4,493	5%
50%	4,544	6%
60%	4,595	7%
70%	4,658	9%
80%	4,728	10%
90%	4,820	13%
100%	5,171	21%

What if Elements Costs are Correlated?



- Often, the costs of two or more project elements are correlated
- Correlation means that two elements' costs “move together”
 - When one is above its mean (expected) value
 - The other one is also above its expected value
- Correlation is defined between 2 elements at a time
 - Many can be correlated, pairwise

Correlation



- Correlation arises because each element is driven by the same “risk driver”



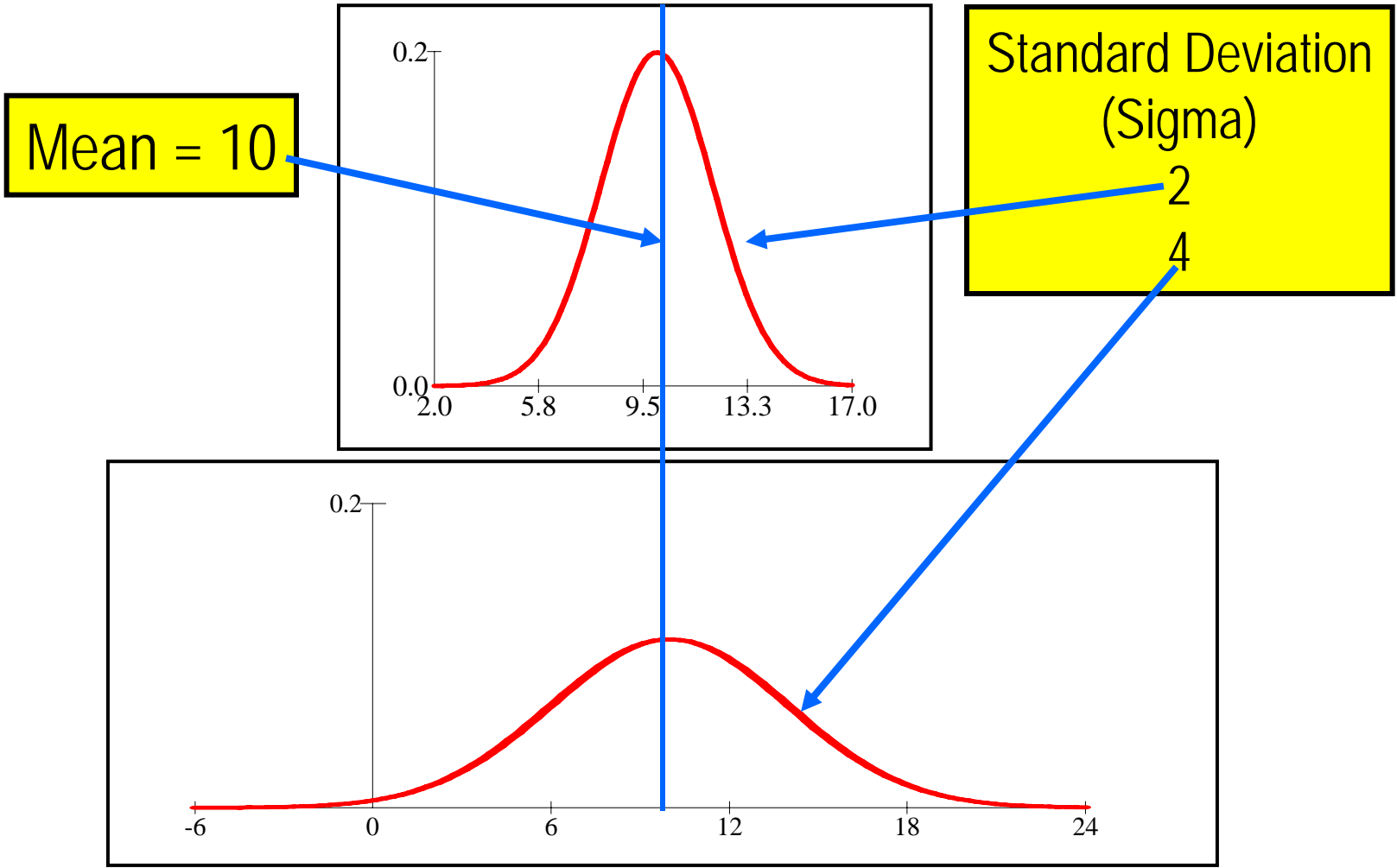
- Correlation is defined between - 1.0 and + 1.0
- There is usually partial (not perfect) correlation

Positive Correlation



- Correlation > 0.0
 - Positive correlation is common in project risk
 - Elements reinforce each other on the project when they are added up – they are high or low together
- Usually result of one common cost driver
- When one element supports another, it is better to model this causal relationship
 - E.g., subcontract management may be defined as 15% of the value of subcontract, by definition

Correlation Increases the Standard Deviation

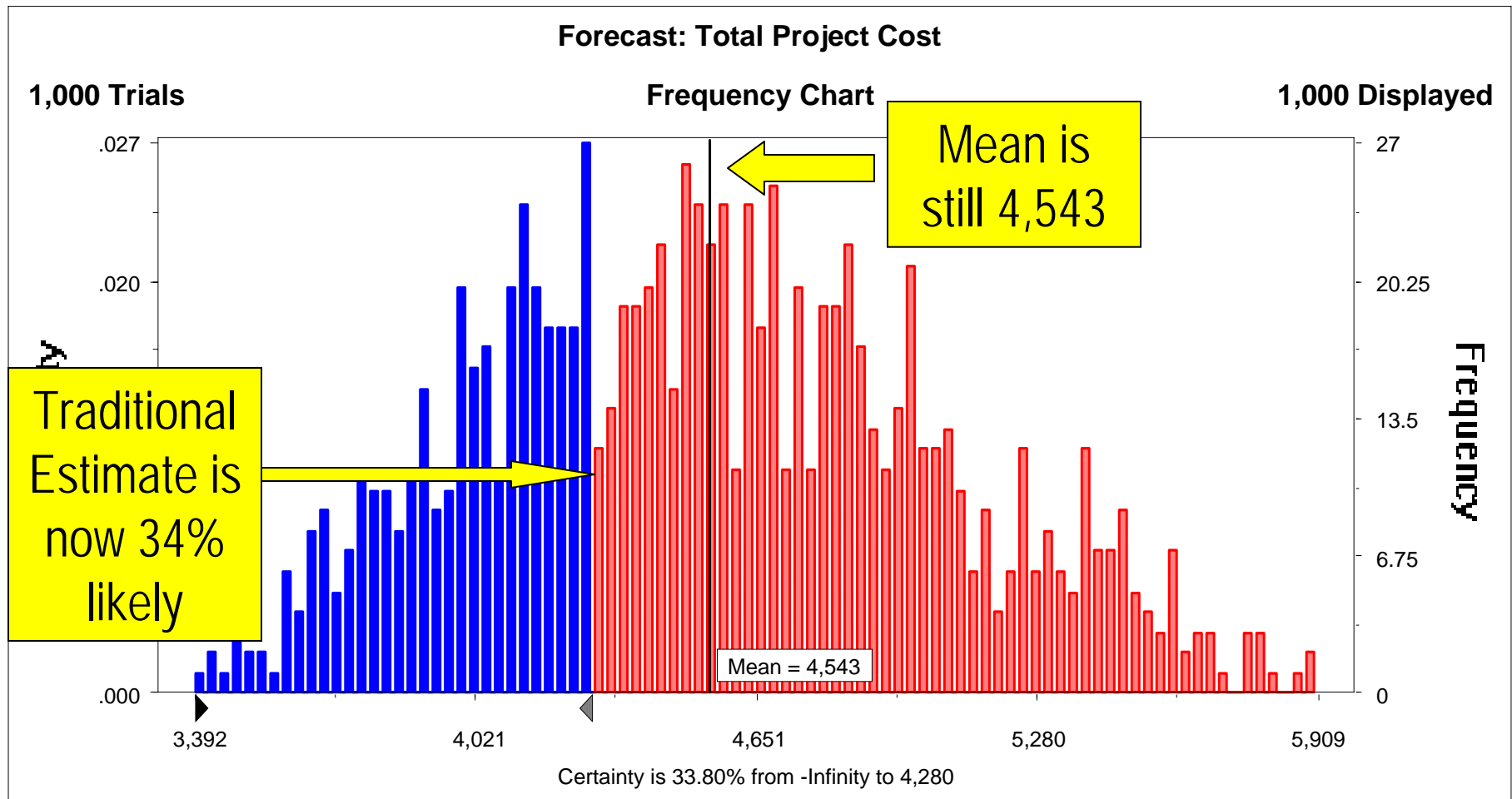


Effect of Correlations -- Spread the Distribution's Tails



- What happens if correlation of each element with the other elements = .8?
 - Spreads the tails of the distribution, extremes reinforce each other when added
 - Mean stays the same, in simple summation model
- Traditional estimate is more likely
- Contingency reserve required is greater for conservative organizations

Correlated Cost Elements



Correlation Spreads the Tails



Contingency Needed for Levels of Safety		
Percentile	No Correlations	Correlations = .8
0%	3,975	3,392
10%	4,261	3,891
20%	4,360	4,083
30%	4,424	4,231
40%	4,493	4,379
50%	4,544	4,519
60%	4,595	4,654
70%	4,658	4,814
80%	4,728	4,991
90%	4,820	5,261
100%	5,171	5,909

Correlation Coefficients are Specified by Expert Judgment



- Historic data can be examined for correlation
 - Data useful for correlation calculation is not often available
- Usually correlation is determined by expert judgment
 - Expert judgment can be unreliable
- Some combinations of correlation coefficients are just not possible
 - They will not happen in nature

Correlation Coefficients Arrayed in a Matrix



Correlation Matrix			
	(1) Design	(2) Tooling	(3) Testing
(1) Design	1.0	Corr. (1,2)	Corr. (1,3)
(2) Tooling	Corr. (2,1)	1.0	Corr. (2,3)
(3) Testing	Corr. (3,1)	Corr. (3,2)	1.0

Example of an Impossible Correlation Matrix



Correlation Matrix			
	(1) Design	(2) Tooling	(3) Testing
(1) Design	1.0	0.2	0.9
(2) Tooling	0.2	1.0	0.8
(3) Testing	0.9	0.8	1.0

Software performs the “eigenvalue test” to determine if the coefficients are possible

One Possible Repair of the Correlation Matrix



Correlation Matrix			
	(1) Design	(2) Tooling	(3) Testing
(1) Design	1.0	0.2	0.9
(2) Tooling	0.2	1.0	0.6
(3) Testing	0.9	0.6	1.0

Finding the Riskiest Cost Elements



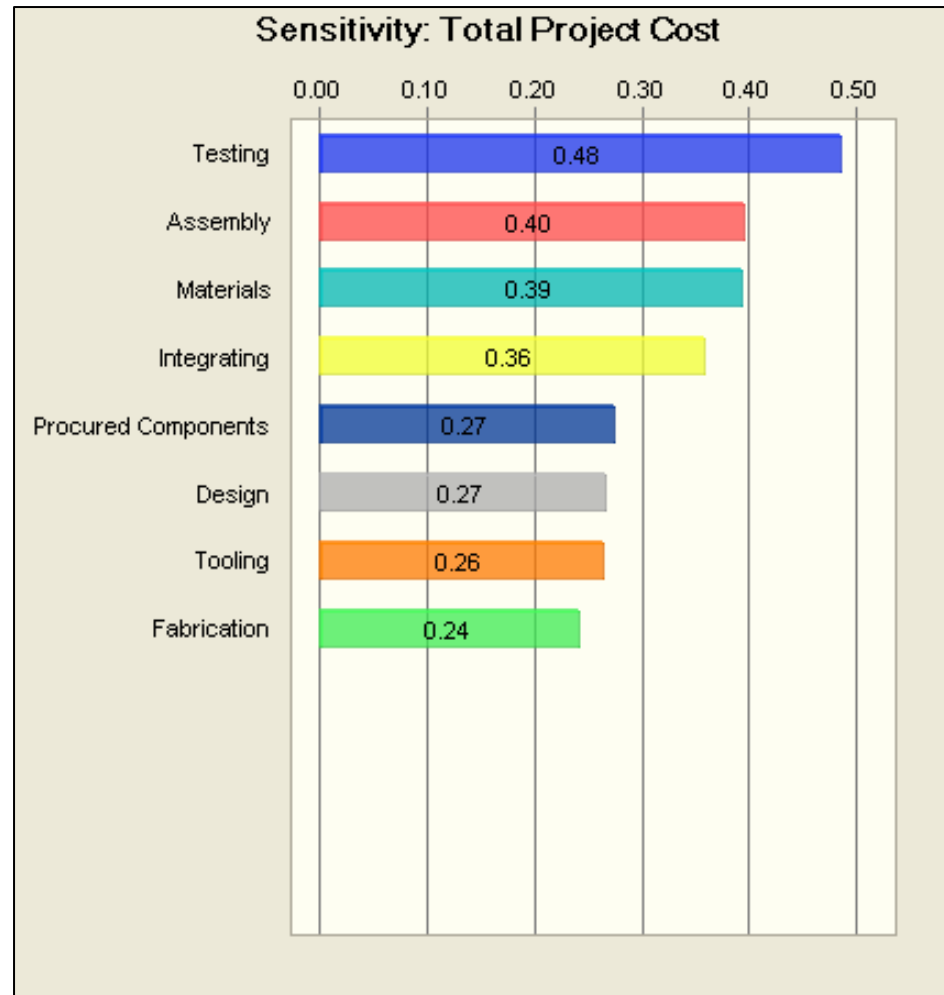
1. Sensitivity Chart

- Provided in the software

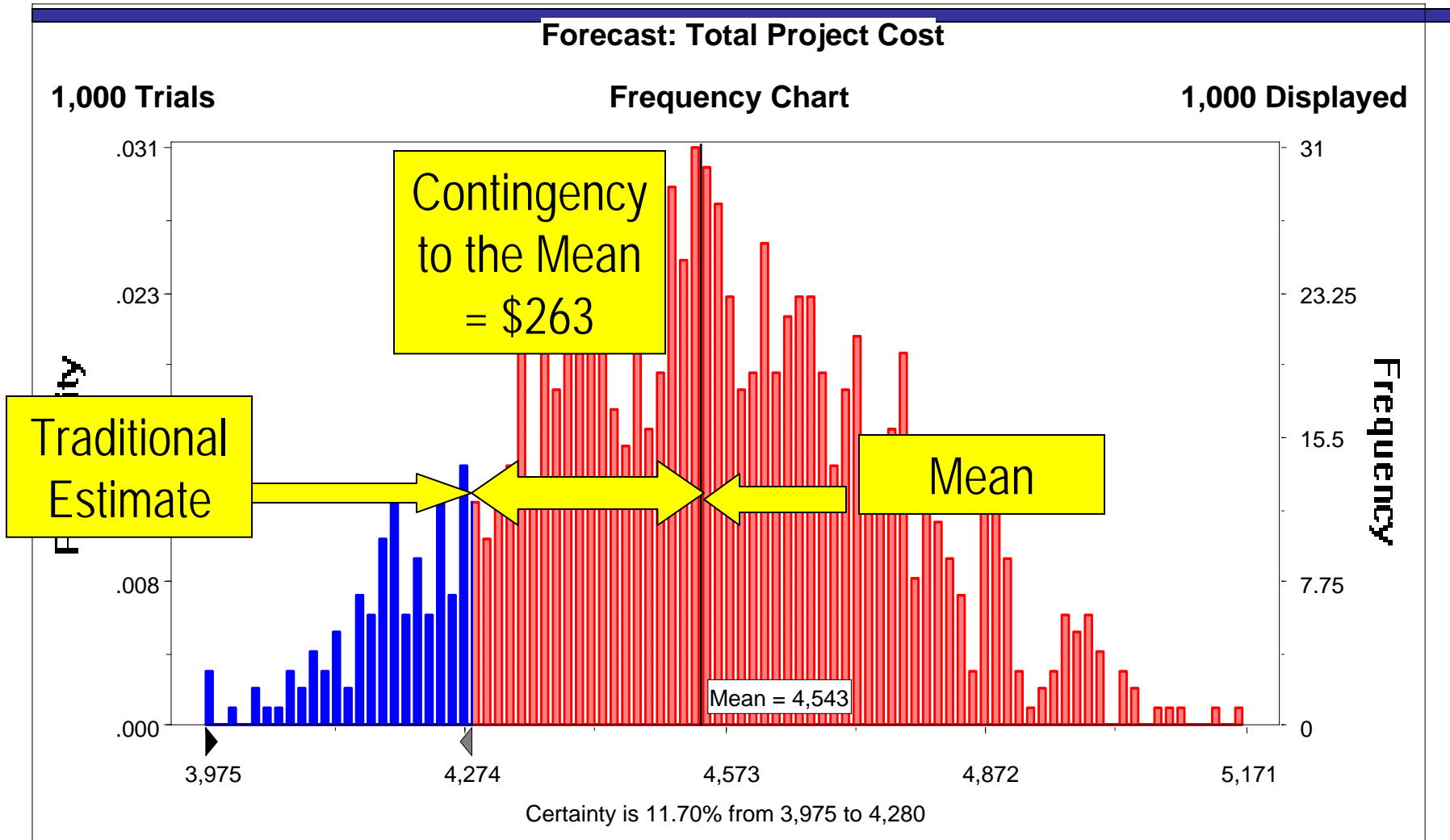
2. Use the Method of Moments to find the contingency to the mean

- Analyze the individual elements to “explain” the contingency to the mean
- Which of the cost elements contributes the most to the need for a contingency of \$263?

Sensitivity Chart



Cost Risk: Results of the Monte Carlo Simulation

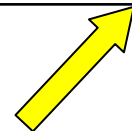


Which are the Riskiest Cost Elements?



Project Cost Risk Priority Calculations at the Mean					
Cost Element	Estimate	Optimistic	Pessimistic	Mean	Contingency
Testing	400	260	750	470	70
Tooling	375	300	570	415	40
Assembly	645	500	900	682	37
Integration	500	375	735	537	37
Materials	500	350	750	533	33
Design	250	175	425	283	33
Procured Components	830	700	1,000	843	13
Fabrication	780	650	910	780	0
Total Project Cost	4,280			4,543	263

Sorted on Mean - Estimate





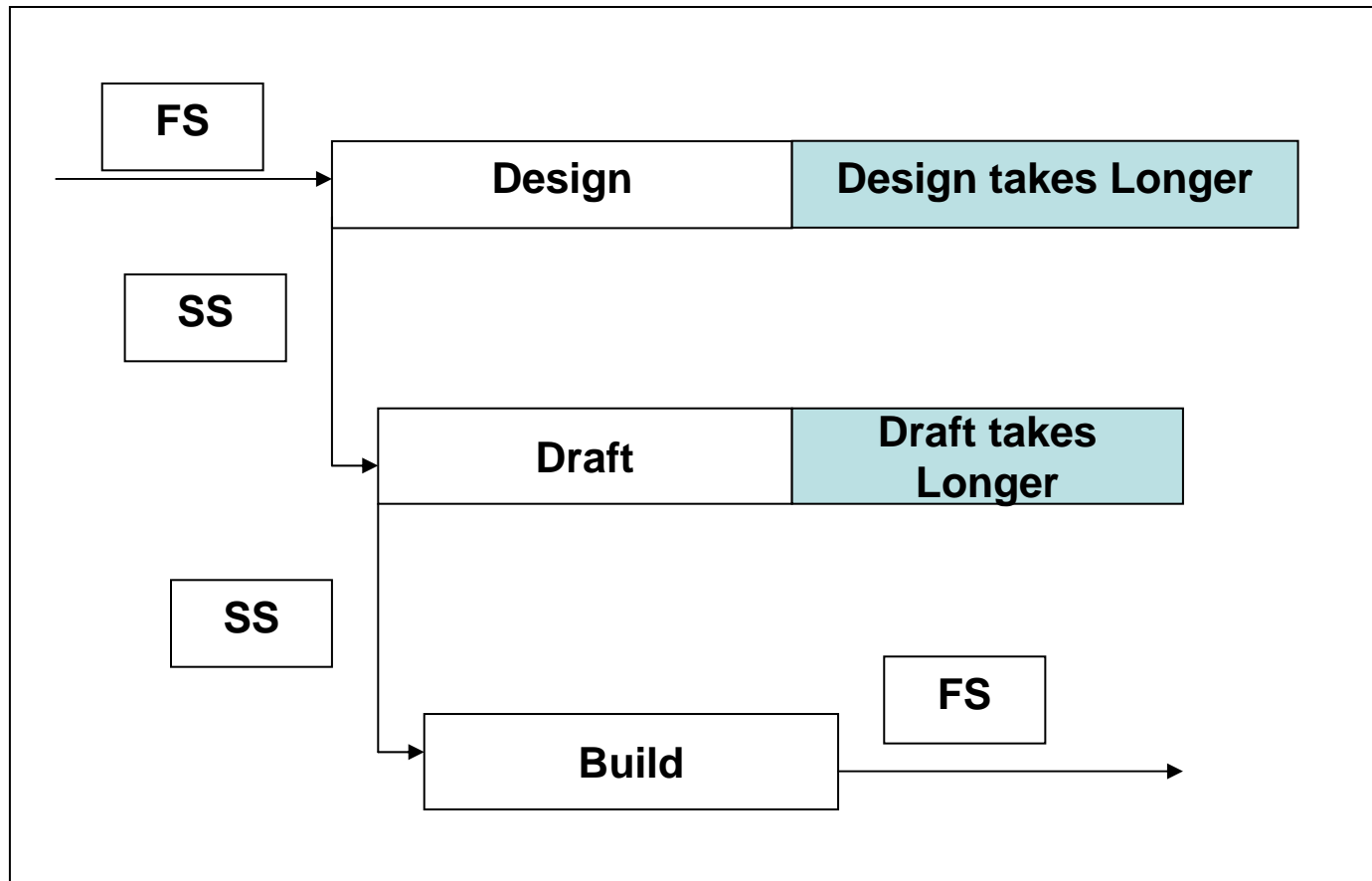
Schedule Risk Analysis

Good Critical Path Method (CPM) Schedules are Needed



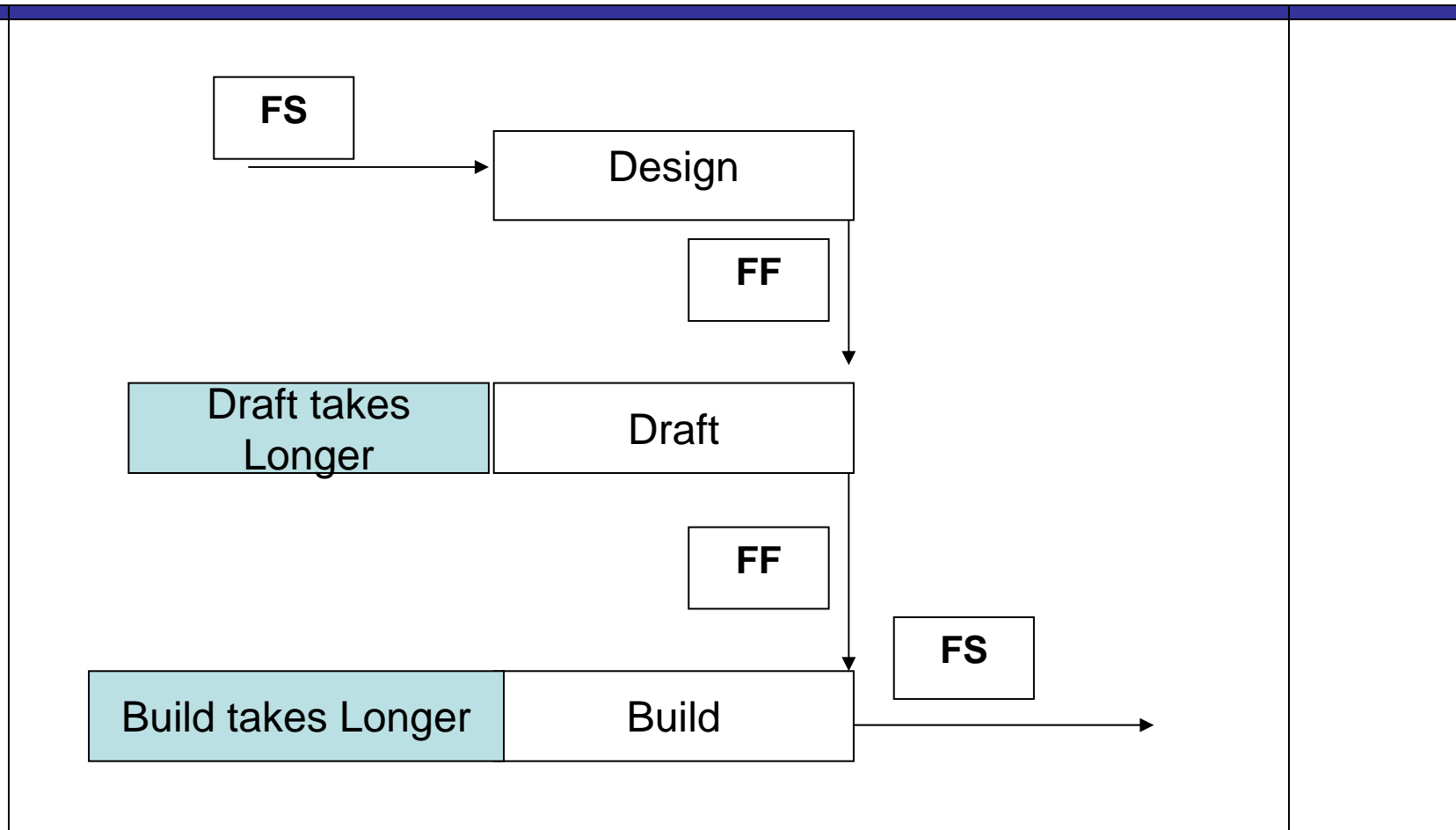
- Schedules should be direct, ***finish-to-start***
- Each activity except the finish milestone needs a successor
- Do not use milestones to stand in for activities
 - Supplier’s “Promise dates” do not mean certainty
- Check floats to see if logic needs fixing
- Schedule as if the durations are uncertain
 - Because they are

Problem with Start-to-Start Logic



Lengthening of S-S Dangers

Problem with Finish-to-Finish Logic

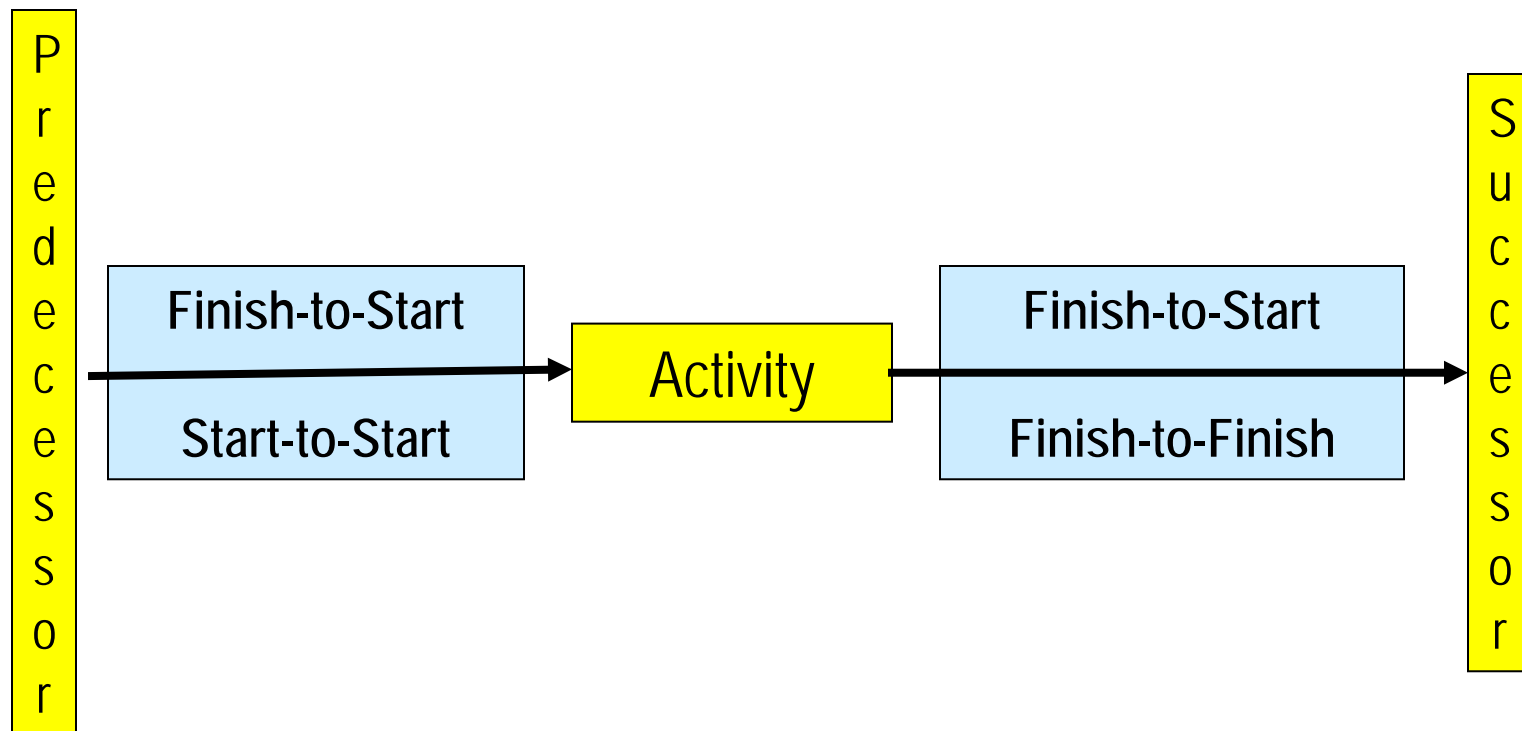


Lengthening F-F Danglers

Standard for Logical Relationships



- Each activity except the finish milestone needs a successor, but that is not sufficient
- The standard is the following:



Resources, Constraints

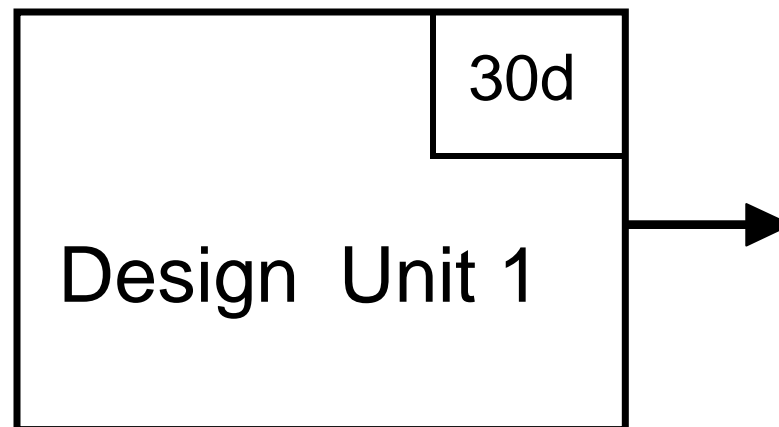


- If resources are scarce in CPM, they should be considered in a risk analysis
- Let the duration and logic drive the dates
 - Do not use constraints or artificial lags between activities to determine when activities start or finish
- Check each constraint that is not “as soon as possible”
 - Some “Start Not Earlier Than” constraints justified
 - All “Finish Not Later Than” or “Finish On” should be eliminated

Risk of an Individual Activity



- Simple activity duration estimates are risky

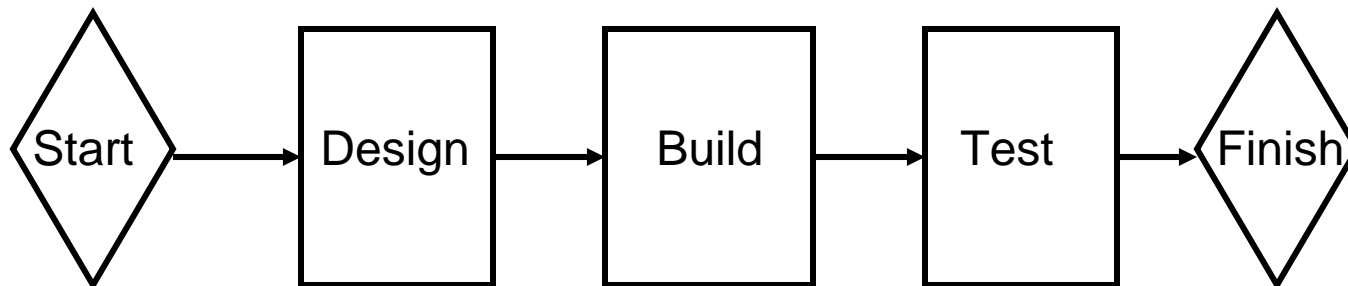


- Activity duration risk is similar to cost element risk
- Different distributions can be used

Risk Along a Schedule Path



- Path risk is the combination of the risks of its activities
- This is also like cost risk to get the risk of the total



One Path Schedule



- This schedule finishes on September 3
 - 7-day weeks, like a model changeover, refinery turnaround

ID	Task Name	Duration	Start						
				May	Jun	Jul	Aug	Sep	Oct
0	One Path Project	95 d	6/1						
1	Start	0 d	6/1						
2	Design Unit	30 d	6/1						
3	Build Unit	40 d	7/1						
4	Test Unit	25 d	8/10						
5	Finish	0 d	9/3						

- If we can get into trouble with this simple schedule, we can get into trouble with real project schedules

Add Duration Risk to the Schedule



ID	Task Name	Rept ID	Min Rdur	ML Rdur	Max Rdur	Curve
1	Project	2	0 d	0 d	0 d	0
2	Start	0	0 d	0 d	0 d	0
3	Design Unit	0	20 d	30 d	45 d	2
4	Build Unit	0	35 d	40 d	50 d	2
5	Test Unit	0	20 d	25 d	50 d	2
6	Finish	0	0 d	0 d	0 d	0

Sensitivity Chart



- Sensitivity of the completion date to the range of each uncertain activity considered one at a time
- This combines the activities' 3-point estimate (high and low only) and their position in the structure of the schedule
- It does not evaluate the impact of all risks together as will happen in the real project

ID	Task Name	Early Fi	Late Fin	Range	August 21	Septemb	Septemb	Septemb	October
5	Test Unit	8/29	9/28	30 d					
3	Design Unit	8/24	9/18	25 d					
4	Build Unit	8/29	9/13	15 d					

Common Sense Results can be Wrong!



“Well, if we just use the right “most likely” durations in our schedules we will get the most likely completion date. Right?”

Wrong!

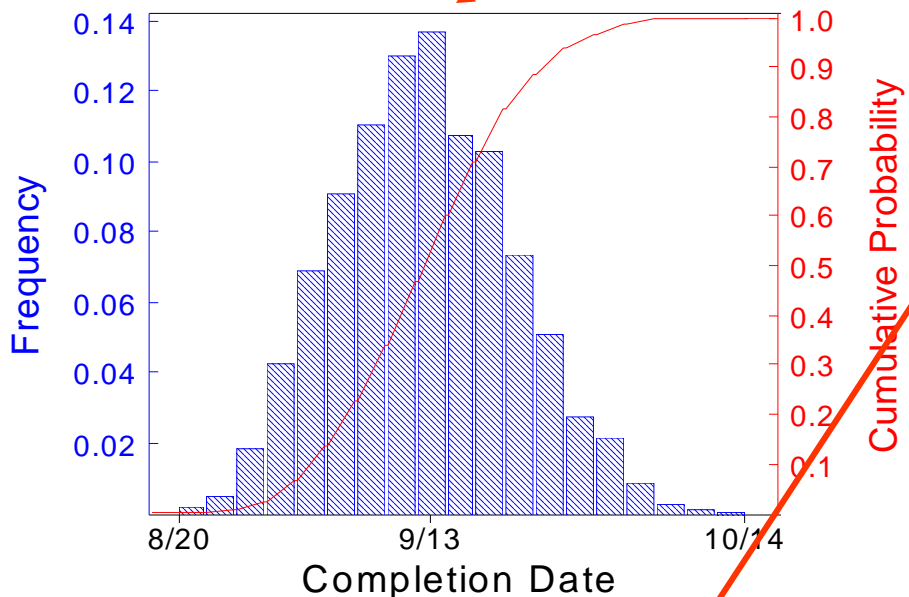
Monte Carlo Simulation Results for One Path Schedule



CPM date is not even the most likely – That's about 9/10

Date: 1/9/2006 7:12:52 PM
 Samples: 3000
 Unique ID: 0
 Name: One Path Project

Completion Std Deviation: 8.82 d
 95% Confidence Interval: 0.31 d
 Each bar represents 3 d



Completion Probability Table

<u>Prob</u>	<u>Date</u>	<u>Prob</u>	<u>Date</u>
0.05	8/31	0.55	9/14
0.10	9/2	0.60	9/15
0.15	9/4	0.65	9/17
0.20	9/6	0.70	9/18
0.25	9/7	0.75	9/20
0.30	9/9	0.80	9/21
0.35	9/10	0.85	9/23
0.40	9/11	0.90	9/25
0.45	9/12	0.95	9/29
0.50	9/13	1.00	10/14

CPM date is <15% Likely to be met

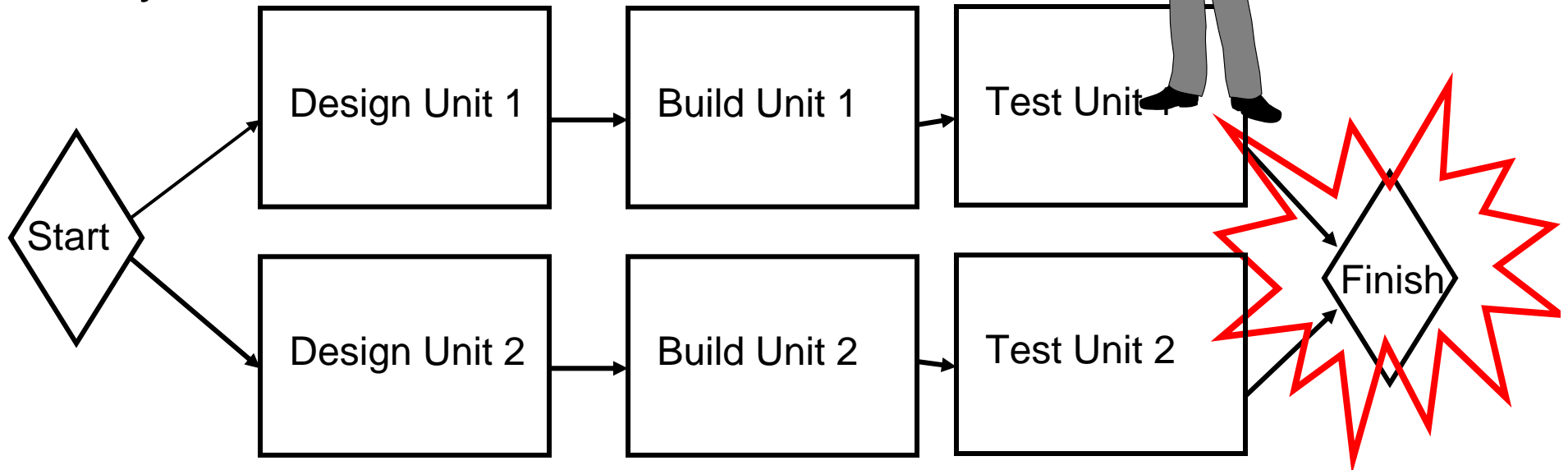
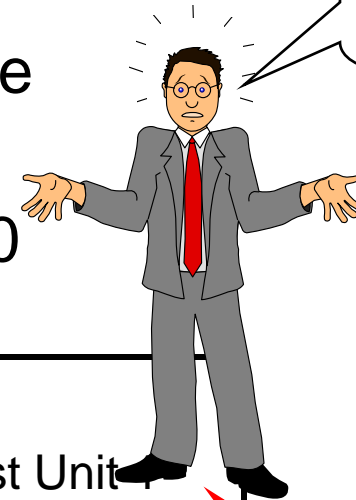
80% Target is 9/21

Risk at Merge Points: The “Merge Bias”



“OUCH!”

- Date for the merge point is driven by the latest converging path
- Merge Bias has been understood for 40 years



Much Schedule Overrun Risk Occurs at Merge Points



- Complex schedules have activities in parallel
- Merge points are important events
 - Completion of the project
 - Major design review
 - Beginning integration and test
- Delay on any path may potentially delay the project
- This extra risk is called the “Merge Bias”

This Schedule has Three Parallel Paths



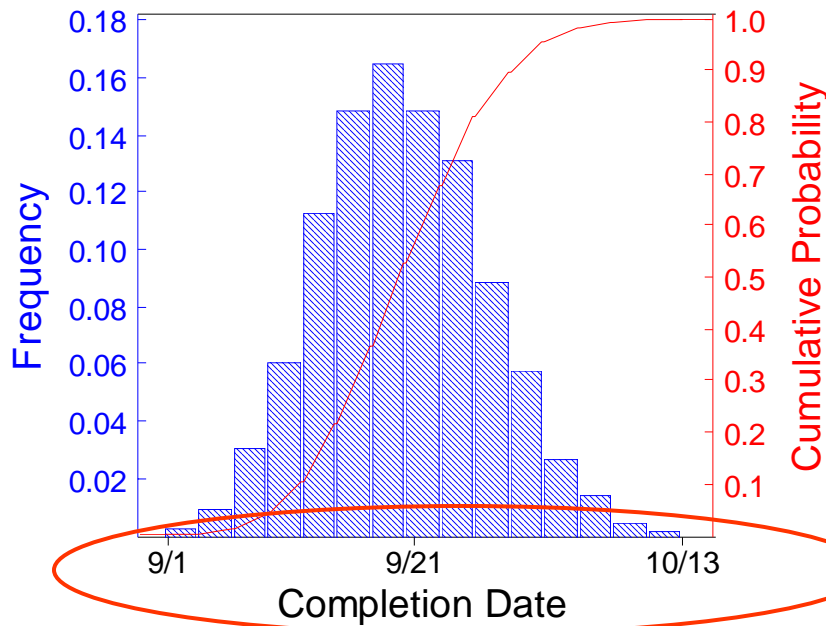
ID	Task Name	Rept IC	Min Rdur	ML Rdur	Max Rdur	Curve	May	June	July	August	Septemb
1	Project	2	0 d	0 d	0 d	0					
2	Start	0	0 d	0 d	0 d	0		6/1			
3	Unit 1	1	0 d	0 d	0 d	0					
4	Design Unit	0	20 d	30 d	45 d	2		6/1	6/30		
5	Build Unit 1	0	35 d	40 d	50 d	2			7/1	8/9	
6	Test Unit 1	0	20 d	25 d	50 d	2				8/10	9/3
7	Unit 2	1	0 d	0 d	0 d	0					
11	Unit 3	1	0 d	0 d	0 d	0					
15	Finish	0	0 d	0 d	0 d	0					9/3

Two paths are collapsed
Each path has exactly the same structure

Evidence of the Merge Bias

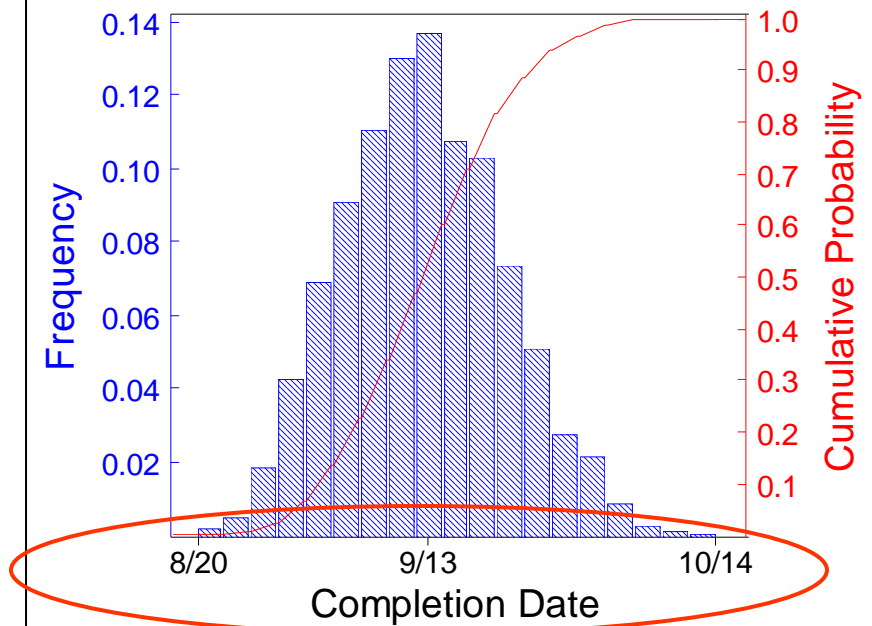


Date: 1/9/2006 7:22:32 PM
Samples: 3000
Unique ID: 0
Name: Three Path Project



Three-Path Schedule

Date: 1/9/2006 7:12:52 PM
Samples: 3000
Unique ID: 0
Name: One Path Project



One-Path Schedule

Evidence of Merge Bias (continued)



Completion Std Deviation: 7.03 d
 95% Confidence Interval: 0.25 d
 Each bar represents 3 d

Completion Probability Table

<u>Prob</u>	<u>Date</u>	<u>Prob</u>	<u>Date</u>
0.05	9/10	0.55	9/22
0.10	9/12	0.60	9/23
0.15	9/14	0.65	9/24
0.20	9/15	0.70	9/25
0.25	9/16	0.75	9/26
0.30	9/17	0.80	9/27
0.35	9/18	0.85	9/29
0.40	9/19	0.90	10/1
0.45	9/20	0.95	10/3
0.50	9/21	1.00	10/13

Three Path Schedule

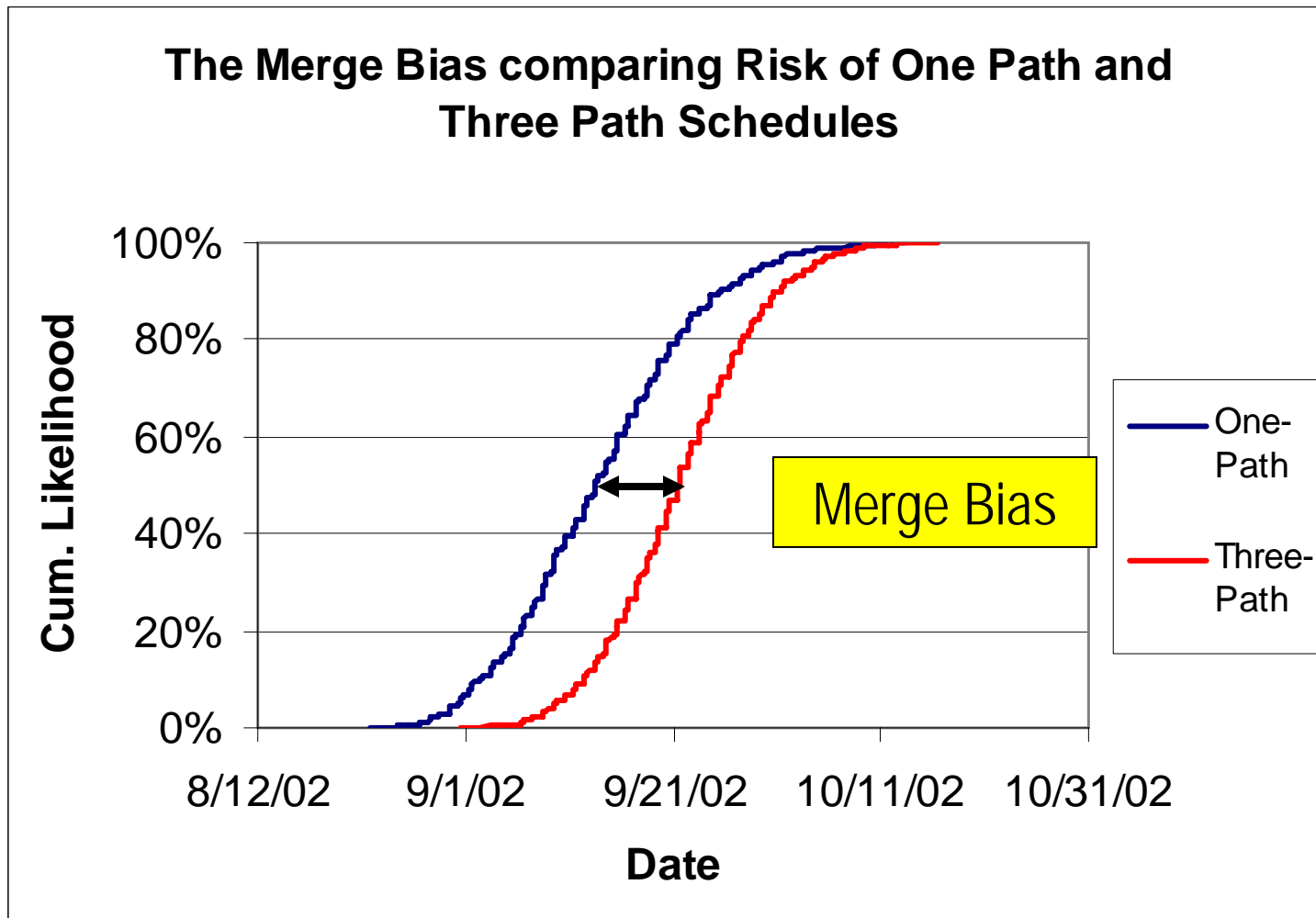
Completion Std Deviation: 8.82 d
 95% Confidence Interval: 0.31 d
 Each bar represents 3 d

Completion Probability Table

<u>Prob</u>	<u>Date</u>	<u>Prob</u>	<u>Date</u>
0.05	8/31	0.55	9/14
0.10	9/2	0.60	9/15
0.15	9/4	0.65	9/17
0.20	9/6	0.70	9/18
0.25	9/7	0.75	9/20
0.30	9/9	0.80	9/21
0.35	9/10	0.85	9/23
0.40	9/11	0.90	9/25
0.45	9/12	0.95	9/29
0.50	9/13	1.00	10/14

One Path Schedule

Graphical Evidence of the Merge Bias



What's Happening Here?

Two Events Occurring at Once



Likelihood of Two Occurances Occuring Together				
Path A	Path B	Path A	Path B	Joint Probability
Complete	Complete	10%	10%	1%
Complete	Not Complete	10%	90%	9%
Not Complete	Complete	90%	10%	9%
Not Complete	Not Complete	90%	90%	81%
Total Likelihood				100%

- Success is only in the green area
- Other scenarios represent failure

Monte Carlo Simulation and PERT



- A Monte Carlo simulation is the modern way to determine the impact of schedule risk at merge points
- An older way was the Program Evaluation and Review Technique (PERT) that used the Method of Moments analysis

PERT was better than single-point scheduling but it always underestimated risk at merge points

What are the Highest Risk Activities?

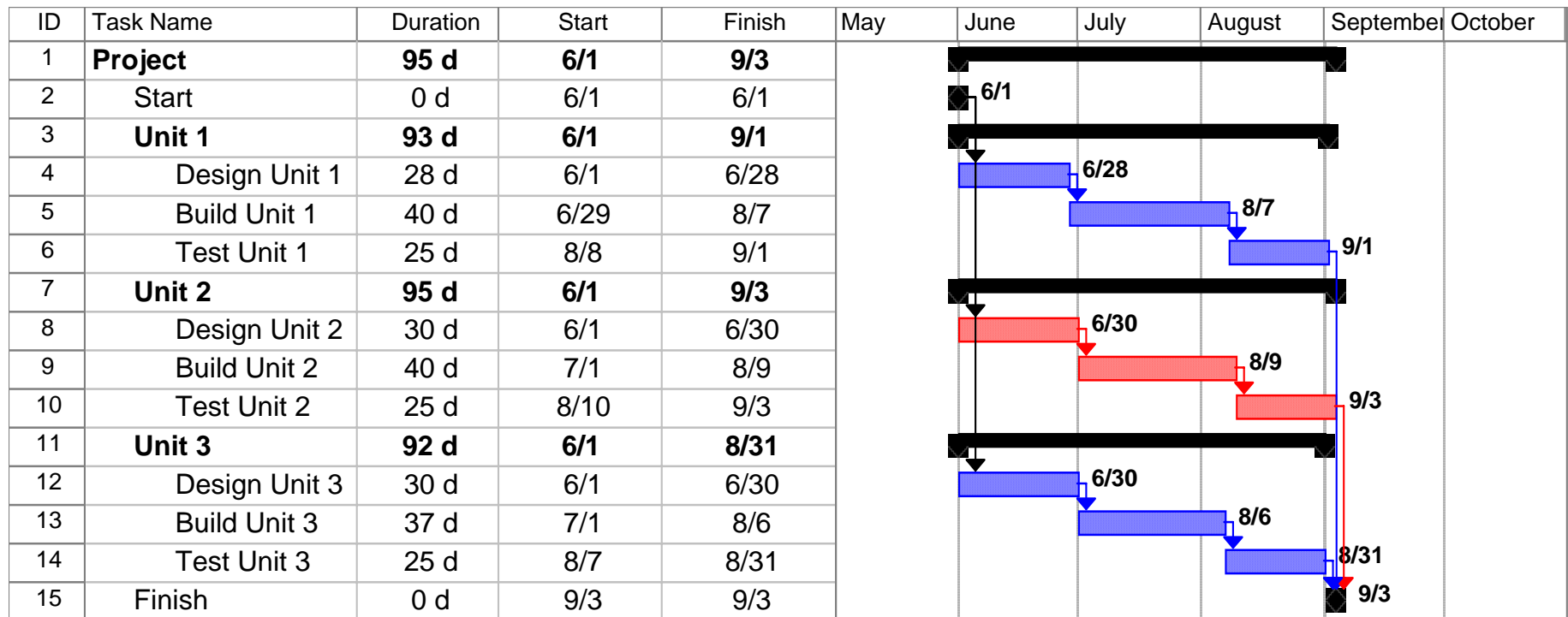


- Monte Carlo simulation
 - Activities on critical path in most iterations
- Path delaying the project may not be the critical path identified by CPM
- This is “Schedule Critical” not Technically Critical
 - Combination of risk and low float (slack)

What are the Highest-Risk Activities?



Units 1 & 3 are Shorter and Not Risk Mitigated



"Critical" Unit 2 is Identified for Risk Mitigation

What are the Highest-Risk Activities? (continued)



ID	Task Name	Rept ID	Min Rdur	ML Rdur	Max Rdur	Curve
1	Project	2	0 d	0 d	0 d	0
2	Start	0	0 d	0 d	0 d	0
3	Unit 1	1	0 d	0 d	0 d	0
4	Design Unit 1	0	18 d	28 d	43 d	2
5	Build Unit 1	0	35 d	40 d	50 d	2
6	Test Unit 1	0	20 d	25 d	50 d	2
7	Unit 2	1	0 d	0 d	0 d	0
8	Design Unit 2	0	26 d	30 d	38 d	2
9	Build Unit 2	0	36 d	40 d	45 d	2
10	Test Unit 2	0	22 d	25 d	35 d	2
11	Unit 3	1	0 d	0 d	0 d	0
12	Design Unit 3	0	20 d	30 d	45 d	2
13	Build Unit 3	0	32 d	37 d	47 d	2
14	Test Unit 3	0	20 d	25 d	50 d	2

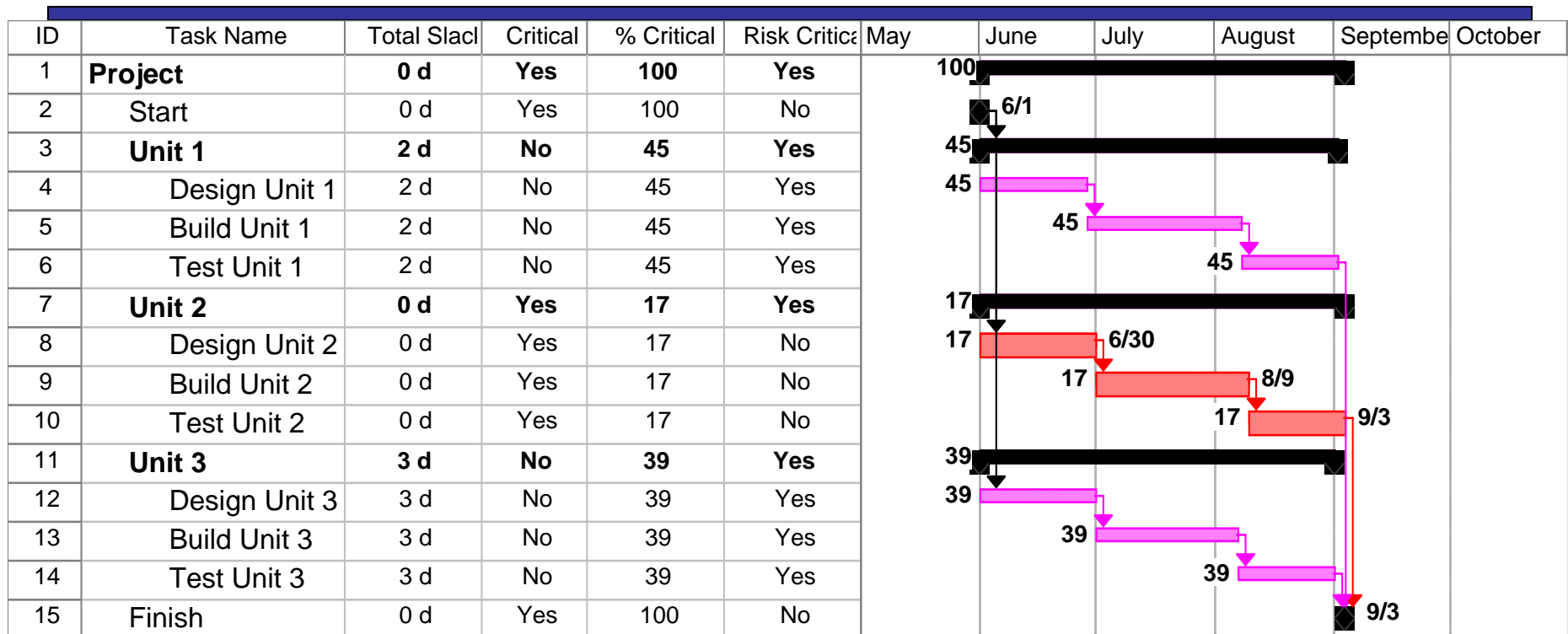
Unit 2 is
Closely
Managed
but Units
1 & 3 still
Have
Risk

Risk Criticality of Activities



- Risk Criticality is the likelihood that an activity will be on the path that delays the project
 - Activity may not be technically risky
 - Activity may not be risky, but path is
- Percentage of iterations on the critical path

Risk Critical Chart



The "Critical Path" has been managed and is only 17% likely to delay the project. Now turn attention to Units 1 & 3

Probabilistic Branching



-
- Many projects have points where there is a possibility of failure, a discontinuous event
 - Have to model the likelihood of the failure and its consequence for the schedule
 - Called “Probabilistic Branching”

A “Test Unit” Task Possibility of a Failure and Having to FIXIT



ID	Task Name	Duration	Min Rcd	ML Rcd	Max Rcd	May	June	July	August	September	October
1	Project	95 d	0 d	0 d	0 d		[Gantt bar from 6/1 to 9/3]				
2	Start	0 d	0 d	0 d	0 d	6/1					
3	Design Unit	30 d	25 d	30 d	65 d	6/1	6/30				
4	Build Unit	40 d	35 d	40 d	50 d		7/1	8/9			
5	Test Unit	25 d	20 d	25 d	50 d			8/10	9/3		
6	Finish	0 d	0 d	0 d	0 d					9/3	

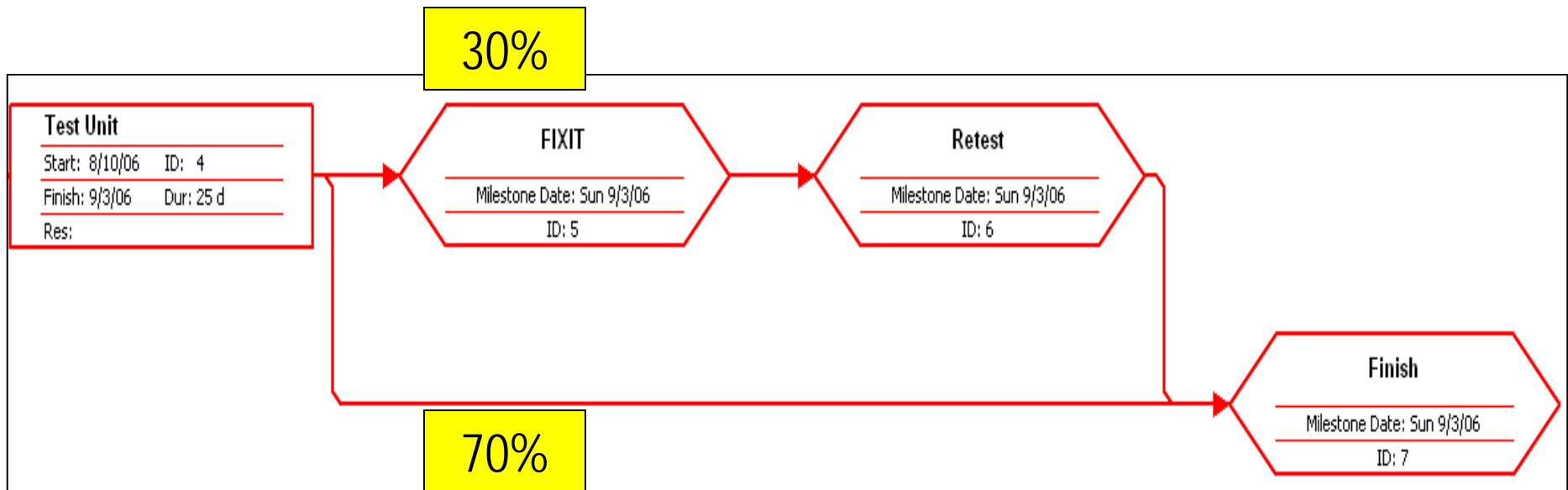
Model the Probabilistic Branch



- Typically do not include failure in schedule
 - Include FIXIT and Retest with 0 duration
 - Preserve the 9/3 finish date
- Enter ranges for the new activities

ID	Task Name	Durati	Start	Finish	Predecess	May	June	July	August	Septem	October
1	Project	95 d	6/1	9/3							
2	Start	0 d	6/1	6/1							
3	Design Unit	30 d	6/1	6/30	2						
4	Build Unit	40 d	7/1	8/9	3						
5	Test Unit	25 d	8/10	9/3	4						
6	FIXIT	0 d	9/3	9/3	5						
7	Retest	0 d	9/3	9/3	6						
8	Finish	0 d	9/3	9/3	7,5						

Logic of Probabilistic Branch

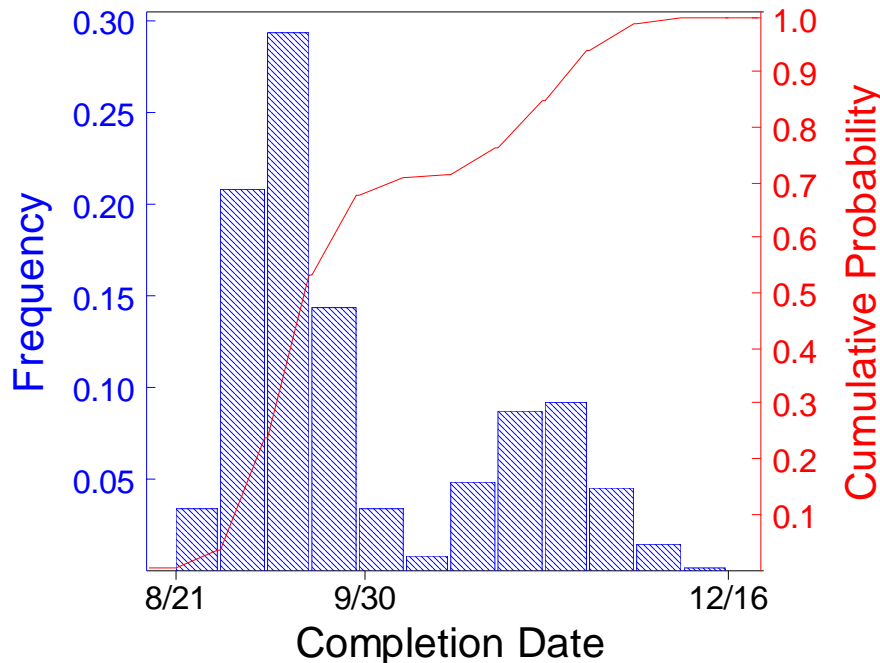


Typical Bi-Modal Result Distribution



Date: 1/9/2006 8:03:50 PM
 Samples: 3000
 Unique ID: 0
 Name: Probabilistic Branch

Completion Std Deviation: 27.45 d
 95% Confidence Interval: 0.98 d
 Each bar represents 10 d



Completion Probability Table

<u>Prob</u>	<u>Date</u>	<u>Prob</u>	<u>Date</u>
0.05	9/1	0.55	9/20
0.10	9/4	0.60	9/23
0.15	9/6	0.65	9/26
0.20	9/8	0.70	10/4
0.25	9/10	0.75	10/28
0.30	9/11	0.80	11/3
0.35	9/13	0.85	11/9
0.40	9/14	0.90	11/13
0.45	9/16	0.95	11/20
0.50	9/18	1.00	12/16

Conditional Branching: Plan A or Plan B?



- Contingency Planning Problem
- Propulsion System Alternative A is preferred by customer
 - Alternative A is new and risky
- Alternative B is the back up
 - Acceptable, not preferred
- We care about the schedule, too
- How long do we stick with Plan A and under what condition do we go to Plan B (Alternative B)?

Schedule with Plans A & B Represented



ID	Task Name	Duration	Start	Finish	2nd Quart	3rd Quart	4th Quart	1st Quart	2nd Quart	3rd Quart
1	Project	300 d	6/1	3/26						
2	Start	0 d	6/1	6/1						
3	Preferred Alt A	300 d	6/1	3/26						
4	Design Alt. A	100 d	6/1	9/8						
5	Build and Test Alt. A	200 d	9/9	3/26						
6	Backup Alt. B	298 d	6/1	3/24						
7	Design Alt. B	85 d	6/1	8/24						
8	Build and Test Alt. B	185 d	9/22	3/24						
9	Finish	0 d	3/26	3/26						

Build and Test Alt. B SNET 9/22, the day after the decision about Alt. A

Risk Information for Plans A and B



Alternative A has Wider Ranges,
Longer Design Time

ID	Task Name	Rept ID	Min Rdur	ML Rdur	Max Rdur	Curve
1	Project	2	0 d	0 d	0 d	0
2	Start	0	0 d	0 d	0 d	0
3	Preferred Alt A	0	0 d	0 d	0 d	0
4	Design Alt. A	0	85 d	100 d	200 d	2
5	Build and Test Alt. A	0	180 d	200 d	275 d	2
6	Backup Alt. B	0	0 d	0 d	0 d	0
7	Design Alt. B	0	75 d	85 d	110 d	2
8	Build and Test Alt. B	0	170 d	185 d	210 d	2
9	Finish	0	0 d	0 d	0 d	0

Alternative B is Less Desirable but
Less Risky

This Schedule Represents No Backup Plan B



ID	Task Name	Duration	Start	Finish	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter	2nd Q
1	Project	300 d	6/1	3/26					
2	Start	0 d	6/1	6/1					
3	Preferred Alt A	300 d	6/1	3/26					
4	Design Alt. A	100 d	6/1	9/8					
5	Build and Test Alt. A	200 d	9/9	3/26					
6	Backup Alt. B	298 d	6/1	3/24					
7	Design Alt. B	85 d	6/1	8/24					
8	Build and Test Alt. B	0 d	9/22	9/22					
9	Finish	0 d	3/26	3/26					

Zero out Build and Test Alt. B so
Alt. A is the only option

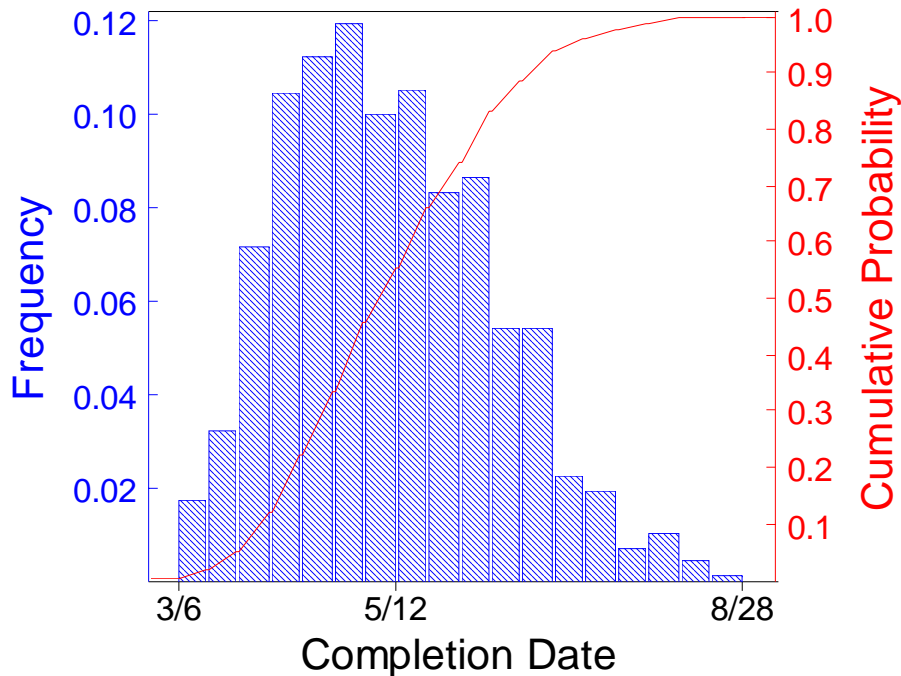
With No Contingency Plan



Date: 2/2/2003 5:32:32 PM
 Samples: 1000
 Unique ID: 2
 Name: Project

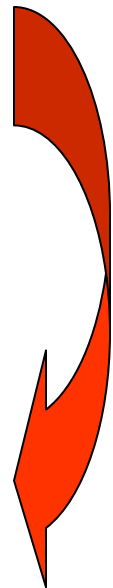
Completion Std Devia
 95% Confidence Inter
 Each bar represents 10 d

80% is 6/10



Completion Probability Table

<u>Prob</u>	<u>Date</u>	<u>Prob</u>	<u>Date</u>
0.05	3/26	0.55	5/14
0.10	4/1	0.60	5/19
0.15	4/8	0.65	5/22
0.20	4/12	0.70	5/29
0.25	4/16	0.75	6/4
0.30	4/20	0.80	6/10
0.35	4/26	0.85	6/18
0.40	4/30	0.90	6/26
0.45	5/4	0.95	7/11
0.50	5/8	1.00	8/28



No Branching: Alternative A is 100% Likely



ID	Task Name	Total Sla	Critical	% Critical	Risk Crit	2nd Quar	3rd Quar	4th Quar	1st Quart	2nd
1	Project	0 d	Yes	100	Yes	100				
2	Start	0 d	Yes	100	No	6/1				
3	Preferred Alt A	0 d	Yes	100	Yes	100				
4	Design Alt. A	0 d	Yes	100	No	100				
5	Build and Test Al	0 d	Yes	100	No		100			
6	Backup Alt. B	187 d	No	0	No					
7	Design Alt. B	215 d	No	0	No	0				
8	Build and Test Al	187 d	No	0	No			9/22		
9	Finish	0 d	Yes	100	No					3/2

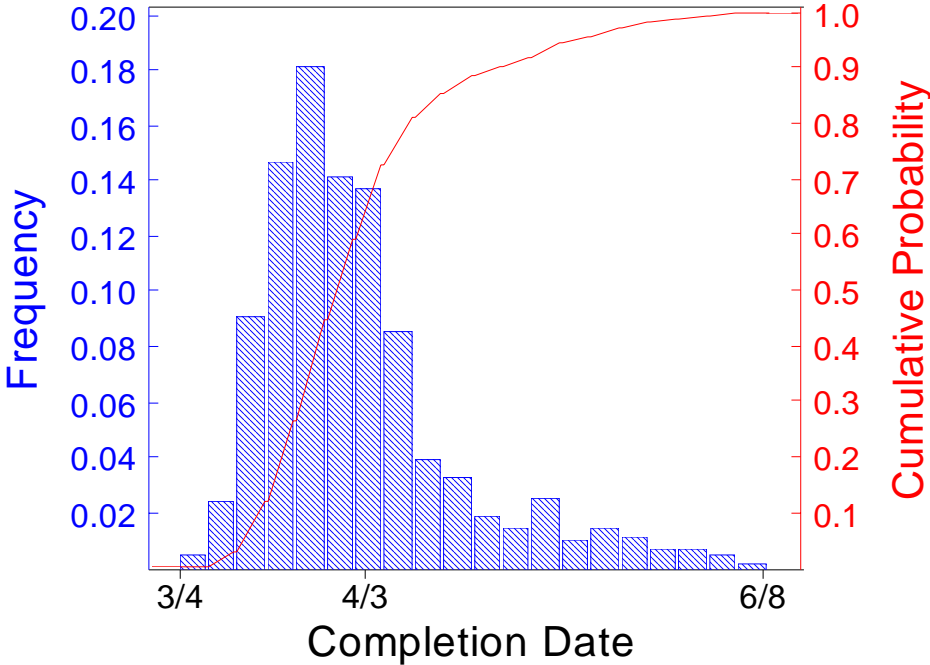
Go to "Plan B" if Design Alternative A is Later than 9/21



Date: 2/2/2003 6:49:27 PM
 Samples: 1000
 Unique ID: 2
 Name: Project

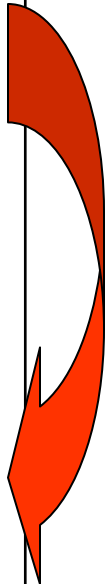
Completion Std Dev: 1.07 d
 95% Confidence Interval: 1.07 d
 Each bar represents 5 d

80% is 4/12



Completion Probability Table

<u>Prob</u>	<u>Date</u>	<u>Prob</u>	<u>Date</u>
0.05	3/15	0.55	4/1
0.10	3/18	0.60	4/3
0.15	3/20	0.65	4/4
0.20	3/21	0.70	4/7
0.25	3/23	0.75	4/9
0.30	3/24	0.80	4/12
0.35	3/26	0.85	4/17
0.40	3/27	0.90	4/26
0.45	3/29	0.95	5/10
0.50	3/30	1.00	6/8



With Branching: Alternative A is only 33% Likely

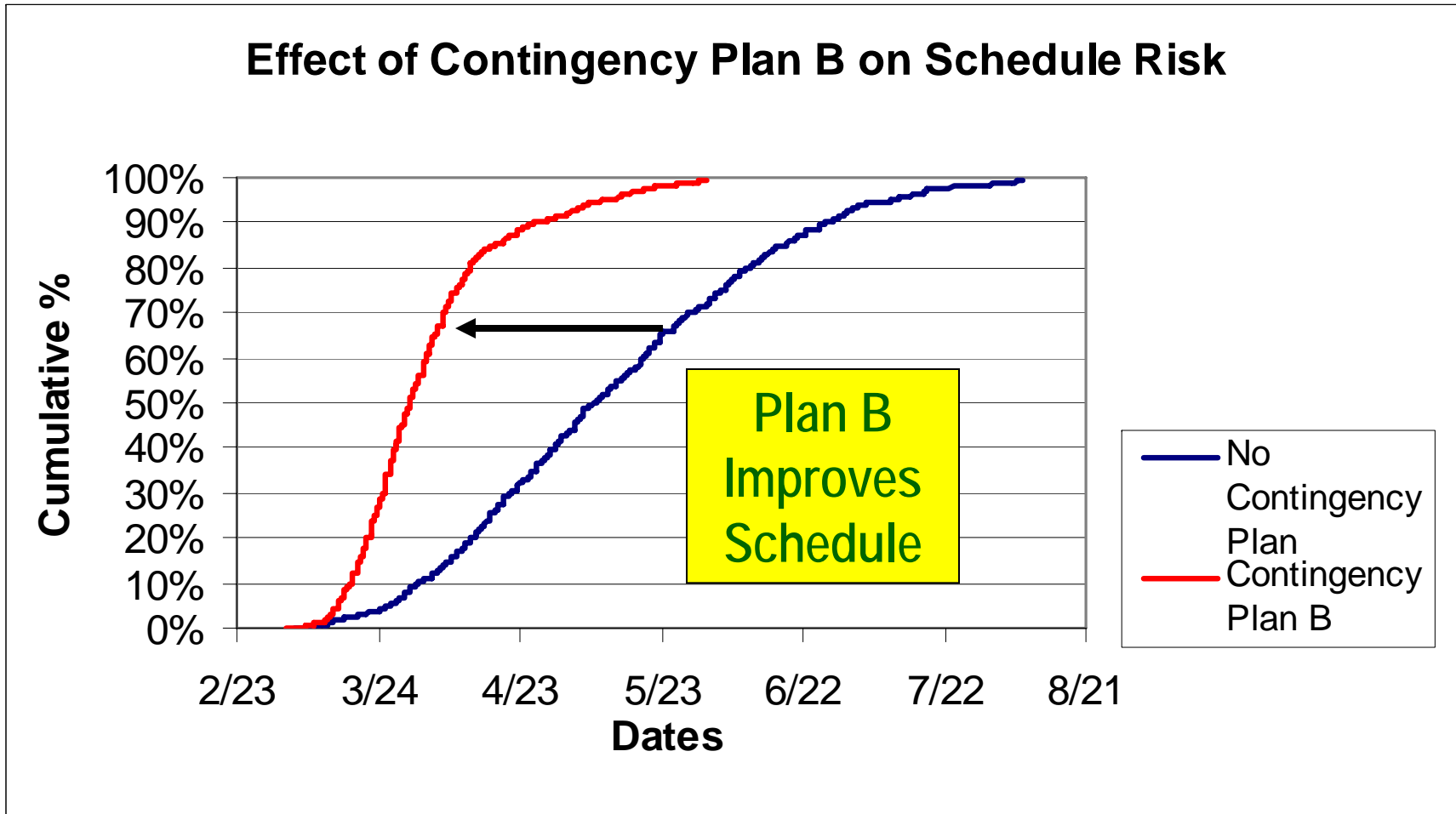


Plan A is Chosen only 33% of the Time

ID	Task Name	Total Slack	Critical	% Critical	Risk Critical	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter	2nd Quarter
1	Project	0 d	Yes	100	Yes	100				
2	Start	0 d	Yes	33	No	6/1				
3	Preferred Alt A	0 d	Yes	33	Yes	33				
4	Design Alt. A	0 d	Yes	33	No	33				
5	Build and Test Alt. A	0 d	Yes	33	No		33			
6	Backup Alt. B	2 d	No	67	Yes	67				
7	Design Alt. B	30 d	No	0	No	0				
8	Build and Test Alt. B	2 d	No	67	Yes		67			
9	Finish	0 d	Yes	100	No					3/26

Plan B is Chosen 67% of the Time

Schedule Improvement from Contingency Plan B



Summary of Conditional Branching Exercise for Contingency Plan



Conditional Branching Results		
Measure of Schedule	Technology A only, No Plan B	Plan B Activated after 9/21
Mean Date	5/12	4/3
Probability 89%	6/10	4/12
Probability using Tech A	100%	33%

Two Major Risk Analysis Concerns



- Organizational culture, bad and good:
 - “I don’t want to hear that” or “shoot the messenger”
- *Versus*
- “There’s going to be good, bad and ugly on this project and I need to know all three”
- Quality data: basis of credibility
 - Data gathering takes time, about 90% of the effort
 - Gathering data about future possibilities is new
 - Most people do not have experience
 - Biases (Motivational and Cognitive) will occur
 - You may need to exclude the project manager from interviews



Project Cost and Schedule Risk Analysis

A presentation to:

NASA Project Management Challenge 2006

David T. Hulett, Ph.D.
Hulett & Associates, LLC



(310) 476-7699 / info@projectrisk.com